CUSTOM SKATEBOARD DESIGN/BUILD PROGRAM

openSource(skateboards);

Contents

Applicable Standards

See specific lesson plans for implementation details.

NGSS:

MS-ETS1-1 Engineering Design: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Common Core:

CCSS.Math.Content.5.G.A.1: Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate).

CCSS.Math.Content.6.NS.C.5: Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.

CCSS.Math.Content.6.NS.C.8: Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.

CCSS.Math.Content.7.NS.A.1: Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram.

CCSS.Math.Content.7.G.A.2 : Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

CCSS.Math.Content.7.G.A.3: Describe the two-dimensional figures that result from slicing three dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids.

CCSS.Math.Content.8.G.A.1: Verify experimentally the properties of rotations, reflections, and translations.

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.HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

CCSS.Math.Content.HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.

CCSS.Math.Content.HSA.REI.B.4: Solve quadratic equations in one variable.

CCSS.Math.Content.HSG.GMD.B.4: Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.

CCSS.Math.Content.HSG.MG.A.1: Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder.

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

CCSS.Math.Content.HSG.MG.A.3 Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

CCSS.ELA-Literacy.RI.6.3: Analyze in detail how a key individual, event, or idea is introduced, illustrated, and elaborated in a text (e.g., through examples or anecdotes).

CCSS.ELA-Literacy.RI.6.7: Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CCSS.ELA-Literacy.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Syllabus

Description:
In this program, students use engineering, technology, and math to design and build their own custom skateboard decks! Students sketch their ideas and convert them into digital drawings using CAD. They hand-shape a foam mold, and use the mold to vacuum-form 7 sheets of maple veneers into a skateboard shape. Students create templates from their CAD models and shape their boards, while learning the safety and basic operation of power tools. After final sanding, the students will seal their skateboard decks and apply art to give their product one last custom touch.

Structure:
This program is broken into four modules, each of which containing more focused lessons:

1) Design and CAD — *Time estimate: basic: 250 minutes; advanced: 450 minutes*
2) Mold Making — *Time estimate: basic: 130 minutes; advanced: 150 minutes*
3) Vacuum Forming — *Time estimate: 150 minutes*
4) Finishing — *Time estimate: basic: 250 minutes; advanced: 350 minutes*

Lessons		Time estimate	Modules
Lesson 1:	User-Focused Design	**(50 min)**	**Design & CAD**
Lesson 2:	Measurements & Sketching	**(50 min)**	
Lesson 3:	CAD Modeling	**(150-350 min)**	
Lesson 4:	Mold Making & Applied Math	**(130-150 min)**	**Mold Making**
Lesson 5:	Vacuum Forming	**(150* min)**	**Vacuum Forming**
Lesson 6:	Woodworking	**(150* min)**	**Finishing**
Lesson 7:	Art & Reflections	**(100-200 min)**	

**Varies with class size*

Before you begin:

- There are a number optional of "advanced" activities, which may be included for more mature students.
- Some students may finish certain activities before other students. Those students may be allowed to help their classmates finish, or they can brainstorm and sketch concepts for their board graphic. Also, the instructor may encourage these students to pursue the "advanced" activities independently or other activities as defined by the instructor.
- Additional handouts, instructor guides, and documentation are provided as attachments to this syllabus.
- A "Comprehension Demonstration" section is included at the end of each lesson plan with relevant questions for students, and may be incorporated as a review or at appropriate times during the lesson.
- Online video links and tutorials are provided when available.

Vimeo Video Password*:

DesignBuildSk8

**This password is required for accessing ad-free video content.*

For questions or additional information:

contact@opensourceboards.com

http://www.opensourceboards.com/contact/

Have Fun!

Lesson 1: User-Focused Design

Standards

NGSS: MS-ETS1-1 Engineering Design: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

Time Estimate: 50 minutes

Learning objectives:

1) Students will make observations about skateboard shapes and their different uses.
2) Students will understand how geometry affects the skateboarding experience.
3) Students will learn about the different components that make up a complete skateboard and their names.
4) Students will learn how to design with constraints.

Lesson outcome:

1) Each student will draw simple sketches of their different skateboard shape ideas within the provided constraints.

Materials:

- Projector or large monitor/screen
- Internet access
- Paper
- Pencils
- Skateboard (optional)

Reference materials:

- *lesson1-slides.pptx* (PowerPoint slides)
- http://bit.ly/SK8CADlite (SK8CADlite - skateboard design CAD software – no download required)

Class breakdown

Appx. time: 5 minutes

Class intros & overview:

Icebreaker: What's your name and what do you like to make?

Process overview (review the process with the class):

<u>What will we do?</u>

Sketch and design your own **custom skateboard deck**

Make your own foam mold **by hand**

Use **vacuum-forming** to **press** your skateboard deck

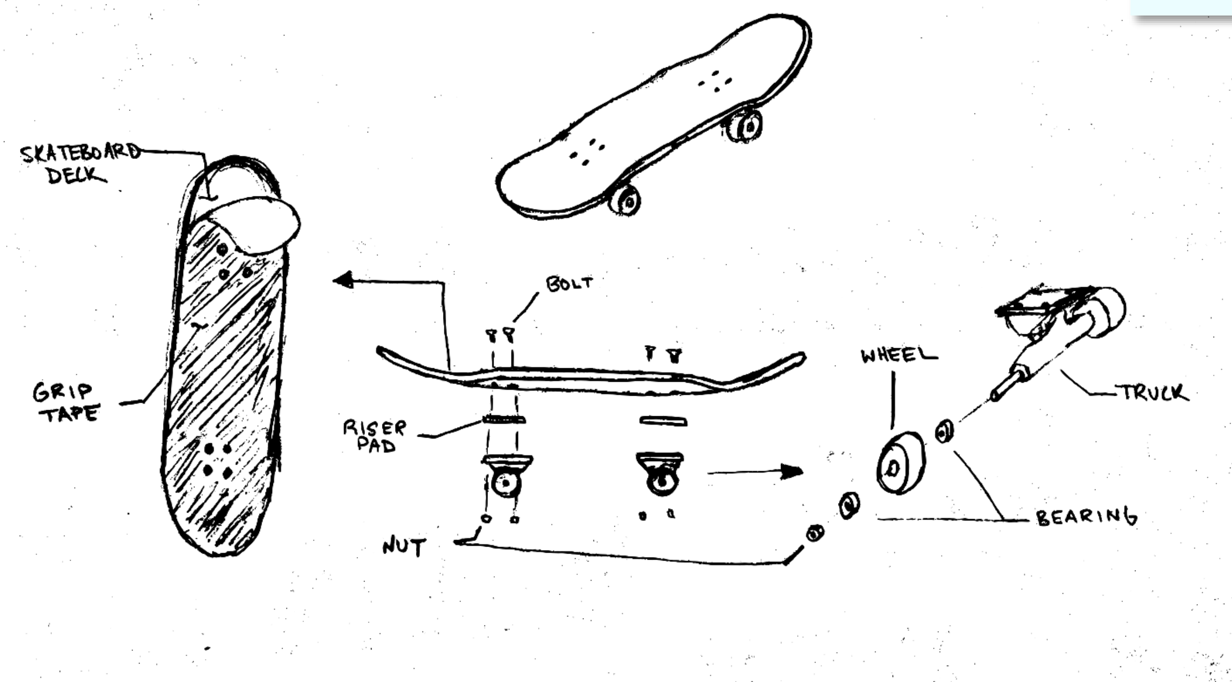
Use power tools to **shape your board**

Sand and drill your board

Put **custom artwork** on your board

<u>Learn: Anatomy of a Skateboard:</u>

Appx. time:
5 minutes



Deck: the platform the skateboarder stands on.

Grip tape: an abrasive, sandpaper-like surface with adhesive on one side for sticking onto your deck. The abrasive side provides grip to prevent the skateboarder's feet from slipping.

Trucks: provide axles for mounting the wheels and allow the skateboarder to turn when leaning left or right. There are **two** trucks per skateboard.

Risers/riser pads: go between the trucks and the deck. They "raise" the deck away from the wheels so that the deck does not touch the wheels on sharp turns. They also provide a cushion for the contact between the hard metal and wood surfaces, which helps to prevent stress cracks in the deck (these may also be called "shock pads"). There are **two** risers per skateboard.

Wheels: typically made of urethane and allow the skateboarder to roll. There are **four** wheels per skateboard.

Bearings: allow the wheels to spin smoothly. There are **eight** bearings per skateboard (**two** per wheel).

Bolts: attach the trucks to the deck when paired with nuts. There are **eight** bolts per skateboard.

Nuts: fasten the trucks to the deck and fasten the wheels to the trucks. There are **twelve** nuts per skateboard (**eight** attach to the bolts and **four** attach to the trucks).

Exercise: "Understanding the User":

Appx. time:
15 minutes

Each student must create a table on paper similar to the following:

Video Number	Observations

The instructor will play the following four videos for the class. Each video highlights a different style of skateboarding. For each video, the students **write down their observations** about the ways the skateboarders are using their boards and the shapes of their boards. For example, is the board flipping around a lot? How big is the board? Are the skateboarders moving fast?

Video 1: https://www.youtube.com/watch?v=og7x7W8qSe0 ("street" skateboarding) (**~3 minutes**)

Video 2: https://www.youtube.com/watch?v=-lHSvsB46Og ("freestyle" skateboarding) (**~3 minutes**)

Video 3: https://www.youtube.com/watch?v=OW-J2pQrlsw (longboarding – downhill, freeride, dancing) (**~4 minutes**)

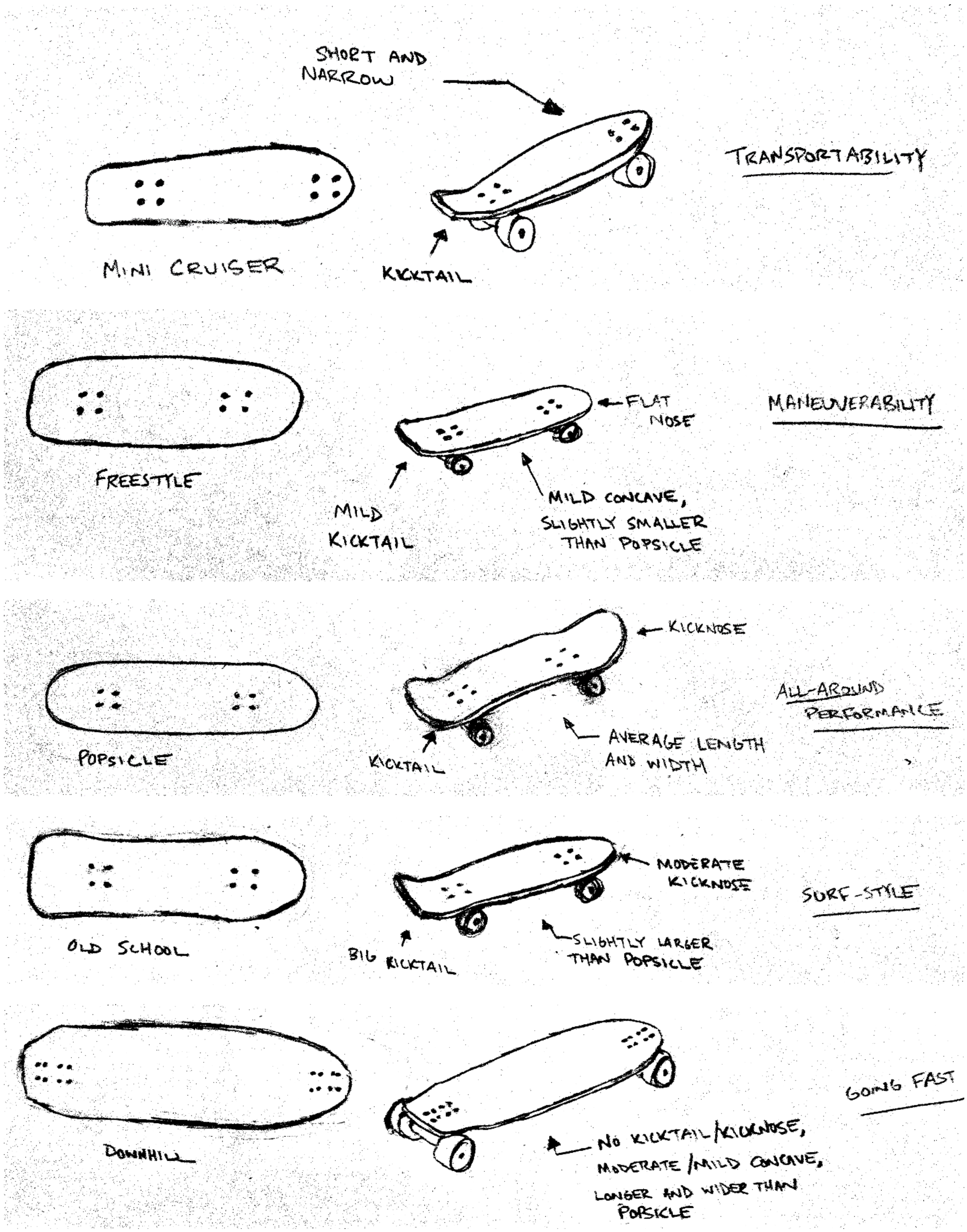
Video 4: https://www.youtube.com/watch?v=TVW0VlyjWOE (cruising/travel) (**~1.5 minutes**)

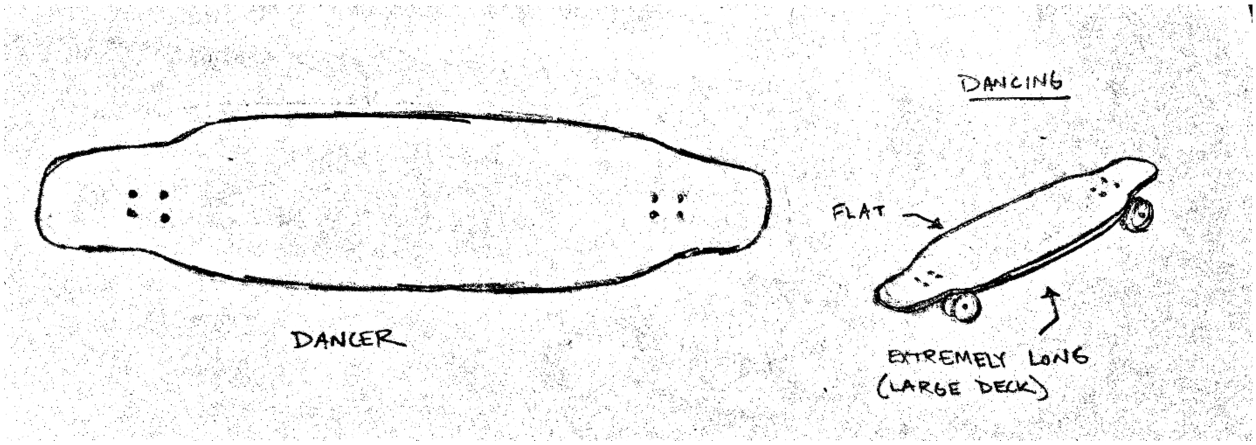
Discussion - Observations:

Appx. time:
5 minutes

Students share what they observed. Class reviews different skateboard types, with instructor facilitating discussion.

Skateboard Types (Sketches):

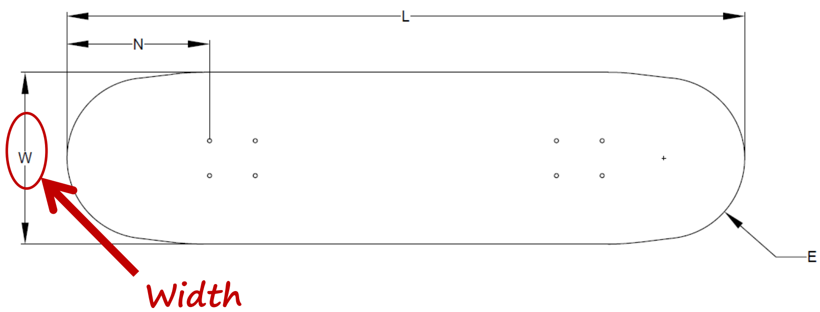


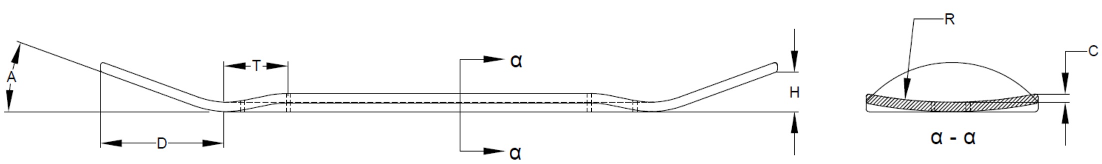


Learn: Skateboard Deck Geometry:

Appx. time:
5 minutes

Width:



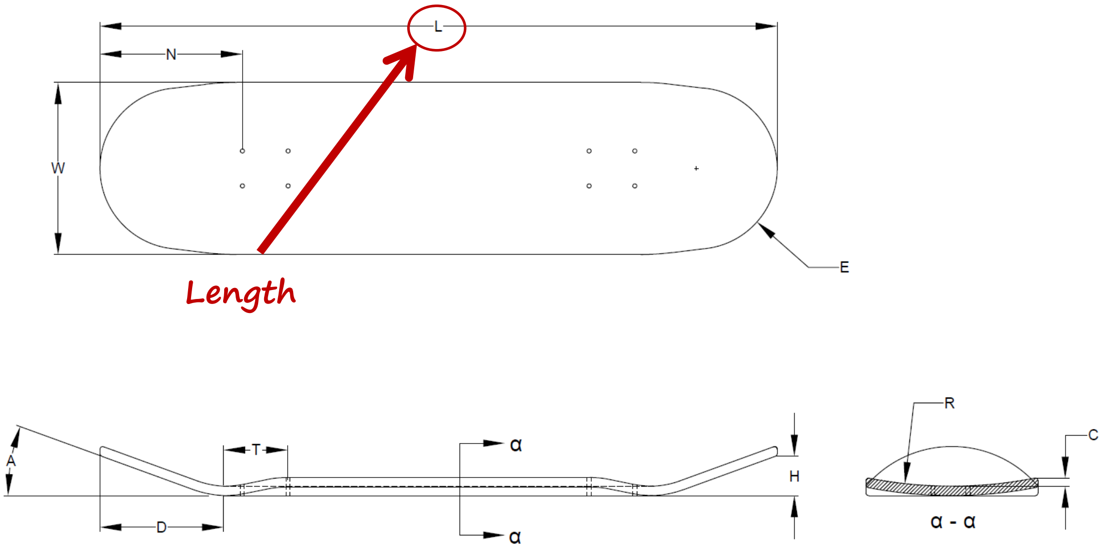


Three different perspectives of a skateboard deck are shown above. The width is one of the most commonly referenced dimensions. It's measured straight across the deck. Too skinny, and your feet will hang off the board, making it harder to balance on. Too wide, and it gets in the way and becomes heavy. In general:

Larger width = more stability, less control

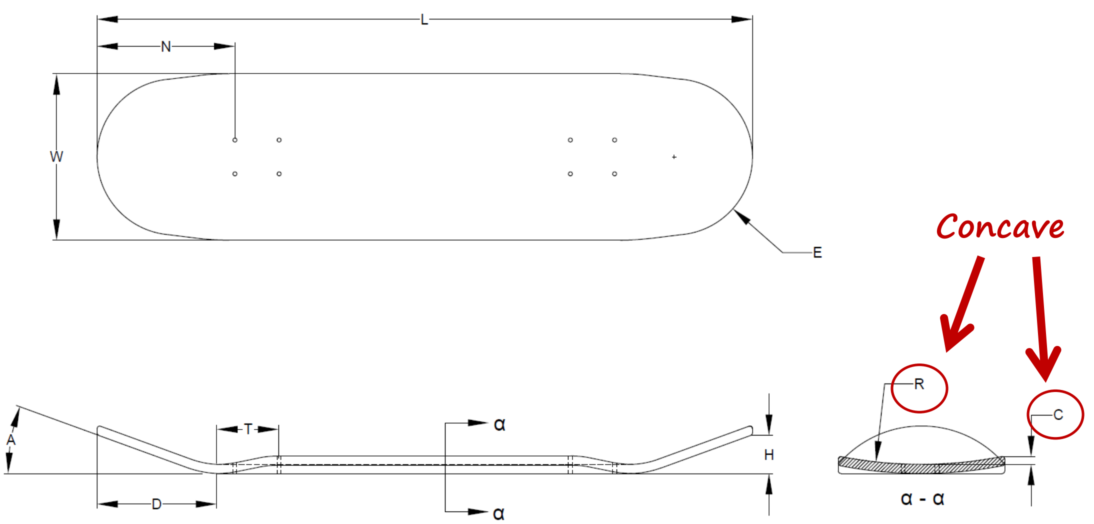
Smaller width = more control, less stability

Length:



Length is measured straight across the length. Like width, a longer board will be heavier and more difficult to control, while a shorter board will be lighter but more difficult to maintain stability.

Concave:

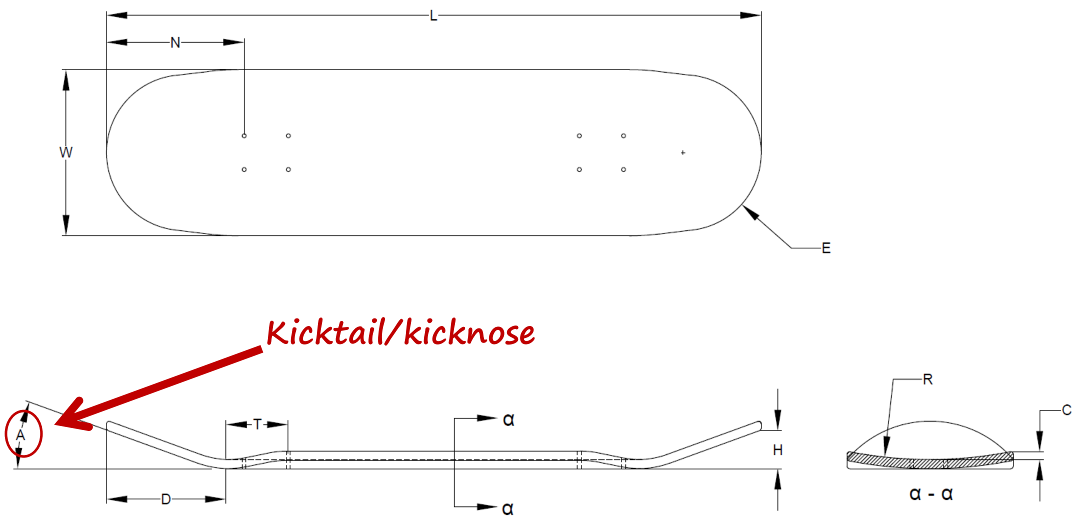


Concave is the curve in the middle of the skateboard. It provides strength/stiffness, as well as "pockets" that help secure the skateboarder's feet or provide leverage for tricks.

> **Exercise:** students take their paper and try to hold it out straight. The paper falls down. Now, have students hold their paper out while creating concave – the paper stays straight out!

In this diagram, "R" refers to the radius of the arc of the concave, and "C" refers to the vertical drop from the edge of the board to the middle.

Kicknose & Kicktail:



The "nose" refers to the front of the board, and the "tail" refers to the back. The kicknose and kicktail are the ends of the board that curve up (the curved feature is called a "kick"). (Some boards are flat, and some may just have a kick on one side – those are sometimes called "single kicks".)

The kick provides leverage, which helps skateboarders do tricks and gain better control of their board.

Sketching:

Appx. time: 15 minutes

Instructor reviews the skateboard design constraints with the students:

Design constraints are limitations on the final product.

Skateboard Design Constraints:

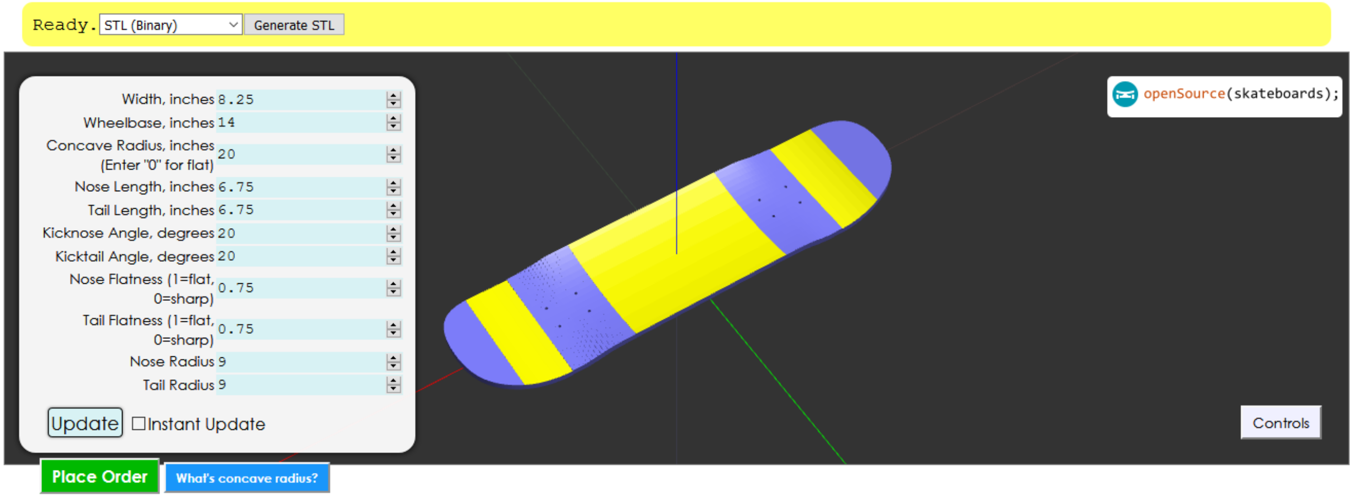
Maximum width	9 inches
Maximum length	33 inches
Maximum kick angle	25 degrees
Maximum wheelbase (to prevent bending)	16 inches
Minimum nose and tail length*	2 inches
Maximum concave drop ("C" dimension)	¾ inches

**To prevent drilling too close to the edge of the board, which could create a failure point.*

Students sketch their ideas using the pencils and paper. Students are encouraged to spend time both sketching independently and discussing their sketches and ideas with other students.

If computers with internet access is available, students may look online at skateboard shapes for inspiration.

Students can also use **SK8CADlite** to design their boards: http://bit.ly/SK8CADlite



The students do not need to dimension their boards at this stage – they are to simply sketch the rough shape they'd like.

Comprehension Demonstration:

1) What are the tradeoffs for the overall size (length and width) of your skateboard?

   Answer: Stability and control – the larger the board, the more stable it is to stand on; the smaller the board, the more control you can have for maneuvering it

2) To make a skateboard deck less flexible, what feature can you add to it?

   Answer: Concave.

3) What is the part of the skateboard called that we are making?

   Answer: The deck.

4) Why do we need to think about how we'll use the board when we're designing it? (For example, would we make the skateboards used in Video #3 for the skateboarders in Video #1?)

   Answer: So that it's easy for you to use! (Open ended answer, encourage class discussion.)

Lesson 2: Measurements & Design

Standards:

Common Core:

[CCSS.Math.Content.7.G.A.3]: *Describe the two-dimensional figures that result from slicing three-dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids.*

[CCSS.ELA-Literacy.RI.6.3]: *Analyze in detail how a key individual, event, or idea is introduced, illustrated, and elaborated in a text (e.g., through examples or anecdotes).*

[CCSS.ELA-Literacy.RI.6.7]: *Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.*

Time Estimate: 50 minutes

Learning objectives:

1) Students will use different perspectives to model their board's design.
2) Students will use cross-sections to show hidden geometry.
3) Students will take accurate measurements with proper units.
4) Students will specify the dimensions of their skateboards.

Lesson outcome:

1) Each student will create a drawing showing the top, side, and cross-sectional views of the skateboard.
2) Each student will have the following dimensions properly labeled on their drawing:
    - Width
    - Wheelbase
    - Nose length
    - Tail length
    - Length
    - Kicktail angle
    - Kicknose angle
    - Concave drop

Materials:

- Tape measures
- Rulers/yard sticks
- Paper
- Pencils
- Students sketches from Lesson 1

Reference Materials:

- *Skateboard Design Guide* (handout packet / link: http://www.opensourceboards.com/skateboard-design-guide/)
- *Skateboard Dimension Template* (handout)

Class breakdown

Reviewing the Board Design Guide:

Appx. time: 5 minutes

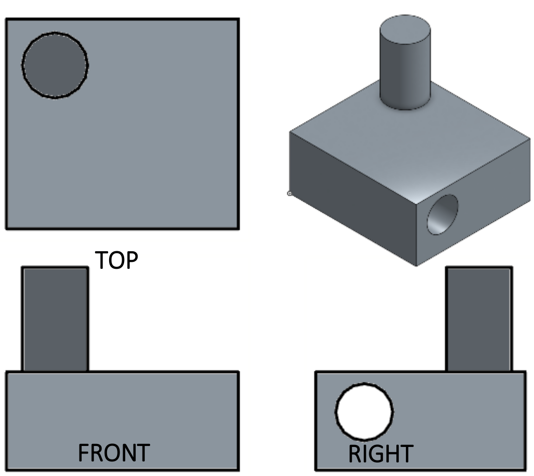
Instructor hands out the *Skateboard Design Guide* (or provides link) and reviews it with the class (and reminds students of constraints).

Learn: Perspectives and Measuring:

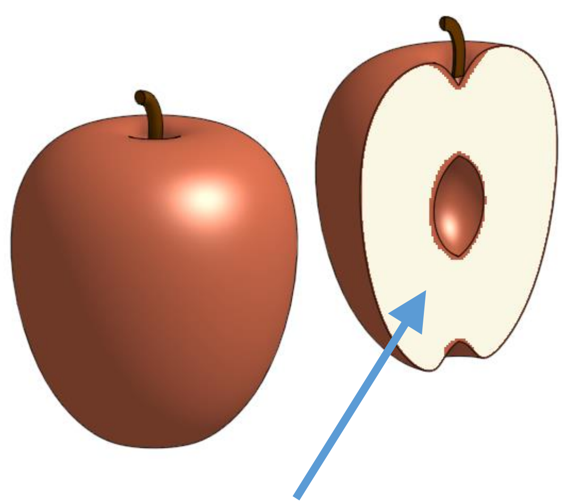
Appx. time: 5 minutes

Objects look different based on where we are standing. Where we stand is our "perspective".

It's necessary to draw different perspectives of an object so that we can see the dimensions of all the features.



Front, right, and top perspectives.



A cross-section allows us to see the core of an apple, which we can't see in the top, side, or front views.

Cross sections allow us to see details that might be hidden from other perspectives.

Measurements:

When measurements are shown on a drawing, they are called "dimensions".

Dimensions need **units** – many rulers and measuring tapes have both **metric** and **imperial** units:

- mm (millimeters) and cm (centimeters) are metric
- in (inches, sometimes shown as ") are imperial

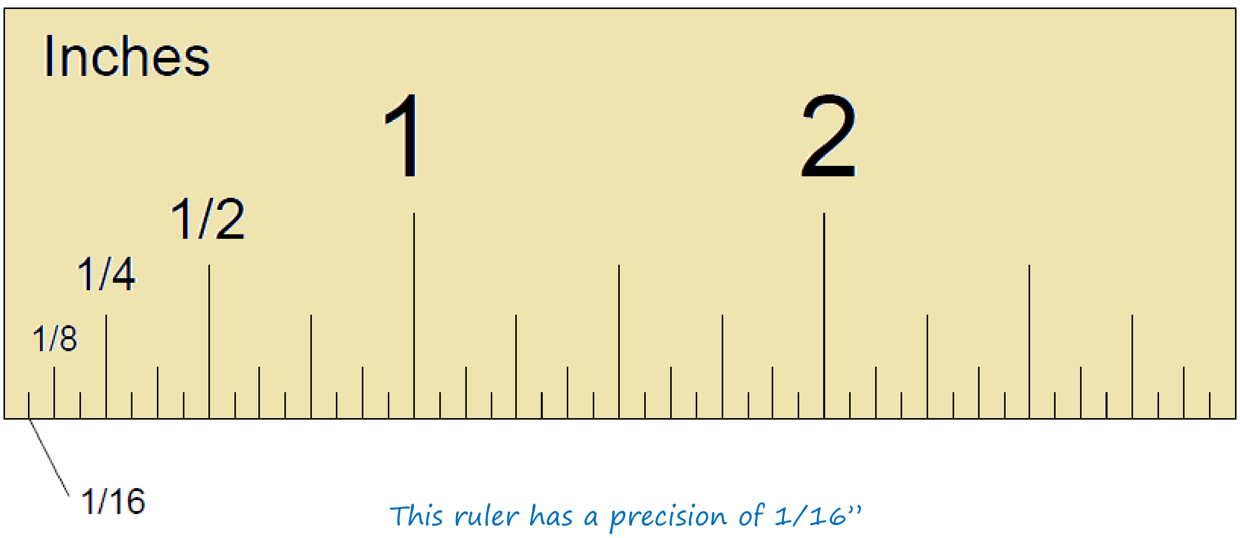
Skateboard dimensions are typically provided in **inches**, so that is what we'll be using.

Rulers and measuring tapes can provide readings at different levels of precision.

Precision is how exact a number is (for example 1.0000 is more precise than 1.0).

Common precision for rulers are 1/8", 1/16", and 1/32".

What is the precision of your rulers?



Exercise: Measuring practice:

Appx. time: 5 minutes

Instructor asks students to make the following measurements and write their answers down on paper:

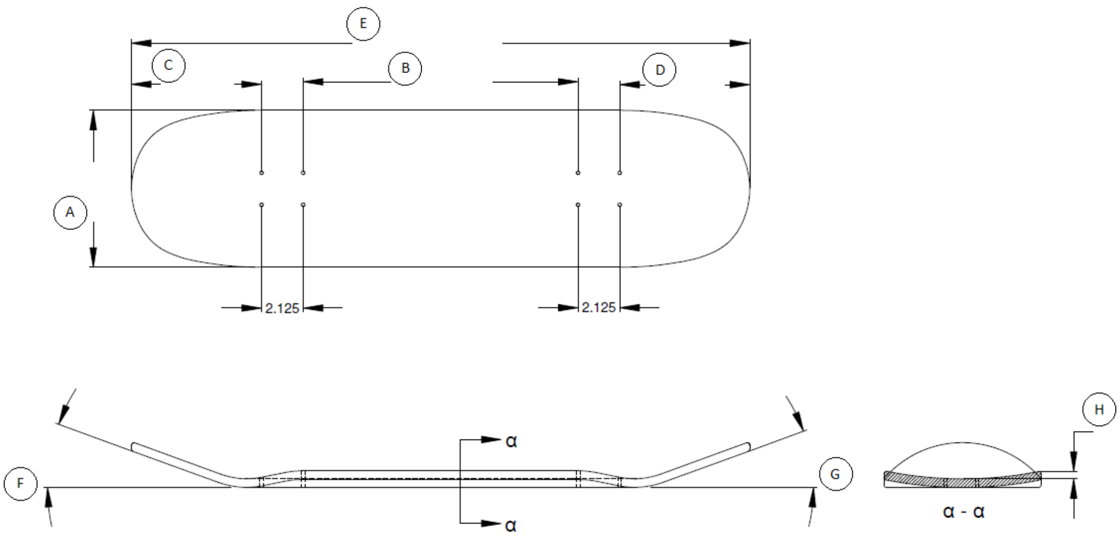
- The length of a pencil
- The width of the student's table/desk
- The length of the student's table/desk

The instructor walks around the room to verify the students' measurements.

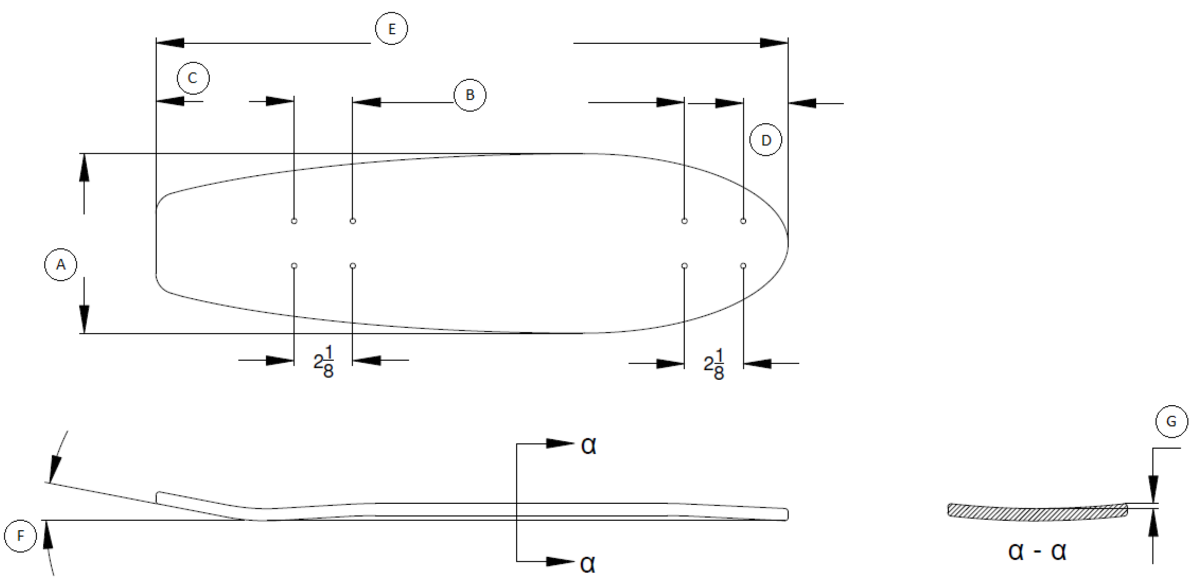
Appx. time: 35 minutes

Create the drawing:

Students can use the **Skateboard Dimension Template** handout to specify the dimensions of their skateboards, using yard sticks and rulers to visualize dimensions.



Popsicle-style template



Cruiser-style template

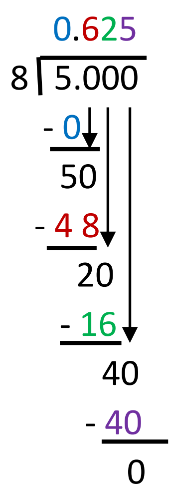
Comprehension Demonstration:

1) Describe/draw the cross sectional views for the following objects:
    a. Pyramid
    b. Donut

    (Instructor will draw on chalkboard/whiteboard the 3D shape and where to take the cross-sections.)

2) Convert the following fractions to decimals:
    a. 1/2
    b. 5-1/4
    c. 3/8
    d. 7/16

    Example: *5/8*



5/8 = 0.625

Lesson 3: CAD (Computer Aided Design)

Standards:

Common Core:

CCSS.Math.Content.5.G.A.1: *Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate).*

CCSS.Math.Content.6.NS.C.5: *Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.*

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CCSS.Math.Content.7.NS.A.1: *Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram.*

CCSS.Math.Content.7.G.A.2 : *Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.*

CCSS.Math.Content.8.G.A.1: *Verify experimentally the properties of rotations, reflections, and translations.*

CCSS.Math.Content.HSG.GMD.B.4: *Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.*

CCSS.Math.Content.HSG.MG.A.1: *Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder.*

Time Estimate: 250 minutes (450 minutes with advanced content)

Learning objectives:

1) Students will learn to use a basic 2D CAD program for creating digital designs
2) Students will use coordinate systems to create their drawings

Advanced objectives:

3) *Students will learn how to layout and create a full CAD drawing of a complex product.*

Lesson outcome:

1) Each student will complete an accurate CAD drawing of the top view of their skateboard deck.
2) Each student will have a print-out of a paper template of their skateboard shape.

Advanced outcome:

3) *Each student will complete a full CAD drawing of their skateboard, including border and title block.*

Materials:

- Computers/laptops with DraftSight Free installed (1 per student)
- Standard computer mouse (1 per student)
- Students' hand-drawn sketches with dimensions
- Scotch tape
- Scissors
- Printer

Reference Materials:

- *DraftSight Cheat Sheet* (handout)
- DraftSight Video Tutorials (playlist link: https://vimeo.com/album/4264653)
- Street Style Skateboard Tutorial (video link: https://vimeo.com/192306225, 15 min)
- Cruiser Style Skateboard Tutorial (video link: https://vimeo.com/192306049, 13 min)
- Printing a Paper Template (video link: https://vimeo.com/192362524, 6 min)

Class breakdown

Appx. time:
5 minutes

Learn: What is CAD?:

CAD stands for Computer Aided Design and it allows us to create 2D and 3D computer models. CAD is very important for a few reasons:

1) It allows us to **visualize and share ideas** before physically producing anything.
2) It allows us **model assemblies and parts** to see or demonstrate how they'll work and interact with each other.
3) It allows us to **create instructions** for machinists and digital fabrication machines which autonomously manufacture a design.

We will be using CAD to create accurate, full-size templates of our boards.

Machines/tools that build things from CAD models:

- 3D printers
- Laser cutters
- CNC mills & routers

Careers that work with CAD:

- Engineers
- Industrial designers
- Architects
- Manufacturers
- Researchers & scientists
- Landscape designers
- Artists & 3D animators

Working in DraftSight:

Appx. time: 45 minutes

Download DraftSight Free: http://www.3ds.com/products-services/draftsight-cad-software/free-download/ (requires e-mail activation – **try to download before this lesson begins**).

Have students open DraftSight on their computers.

DraftSight Tutorial Video Playlist (Vimeo): https://vimeo.com/album/4264653 (see Syllabus for password)

Video 1: Learning the Layout *(4 min)*

Video 2: Basic Shapes *(7 min)*

Video 3: Dimensioning *(3 min)*

Video 4: Formatting dimensions *(3 min)*

Hands-on challenge: Using the "line" tool, make a rectangle with a length of 10, a height of 5, and show both a length and width dimension on your rectangle. *(5 min)*

Video 5: Snaps *(4 min)*

Video 6: Circles and Arcs *(5 min)*

Video 7: Splines *(3 min)*

Video 8: Fillets *(4 min)*

Free Design: Practice using the spline tool to make your own shapes.

Learn: How to Make your Skateboard:

Appx. time: 15 minutes

Show either the street style or cruiser style skateboard design video (or have students watch independently for their specific skateboard style):

Street Style Skateboard Tutorial: https://vimeo.com/192306225, 15 min
Cruiser Style Skateboard Tutorial: https://vimeo.com/192306049, 13 min

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Board Design:

Appx. time: 70 minutes

Students create their skateboard designs in DraftSight, based on their drawings and dimensions. Students that finish early can help their classmates (but not do their classmates' drawings for them!)

Preparing the Template:

Appx. time: 15 minutes

Once all students complete their design, they must draw rectangles around their boards to break the design into printable segments.

Video: Printing a full-size template: https://vimeo.com/192362524, 6 min

Video: Preparing the template: https://vimeo.com/194282901, 1 minute

Students will not print their templates now – this can be done during the glue-up process, while they wait their turns. They will need tape, scissors, and a printer.

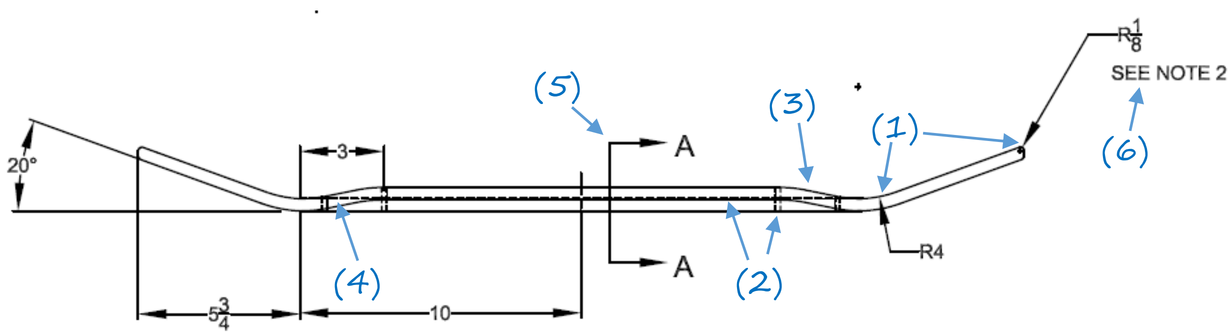
Advanced* Lesson: Creating a CAD drawing

**This lesson is generally recommended for 9th grade an up, only. It is recommended that the instructor have additional experience in CAD to supplement the content in this lesson.*

Appx. time: 200 minutes

Once students have completed their template, they can create a full drawing of their board – a drawing that includes the top view (already completed), side view, cross-sectional view, title block, and border.

Side view:

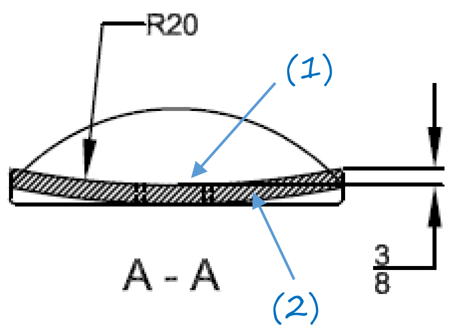


Notable tools used in side view (includes new tools not yet covered):

(1) Fillet – for transition to the kicktail and kicknose, and for the corners of the board.
(2) Dashed line – shows "hidden" lines; geometry of the skateboard that exists, but cannot be directly seen in the current view (like the holes for the bolts).
(3) Spline – for transitioning from the kicktail and kicknose to the concave.
(4) Offset – for creating lines and curves that are perfectly offset from the original lines and curves.
(5) Cross-section label – shows where the cross-section is made and uses arrows to indicate the direction the cross-section perspective is looking.
(6) Text – to list any additional features/instructions not clear from the drawing (not required for this exercise).

A sample drawing (.dxf) can be downloaded at http://www.opensourceboards.com/product/handmade-8-25-mold-1/ (scroll to bottom of page and click "Download zipped .DXF".

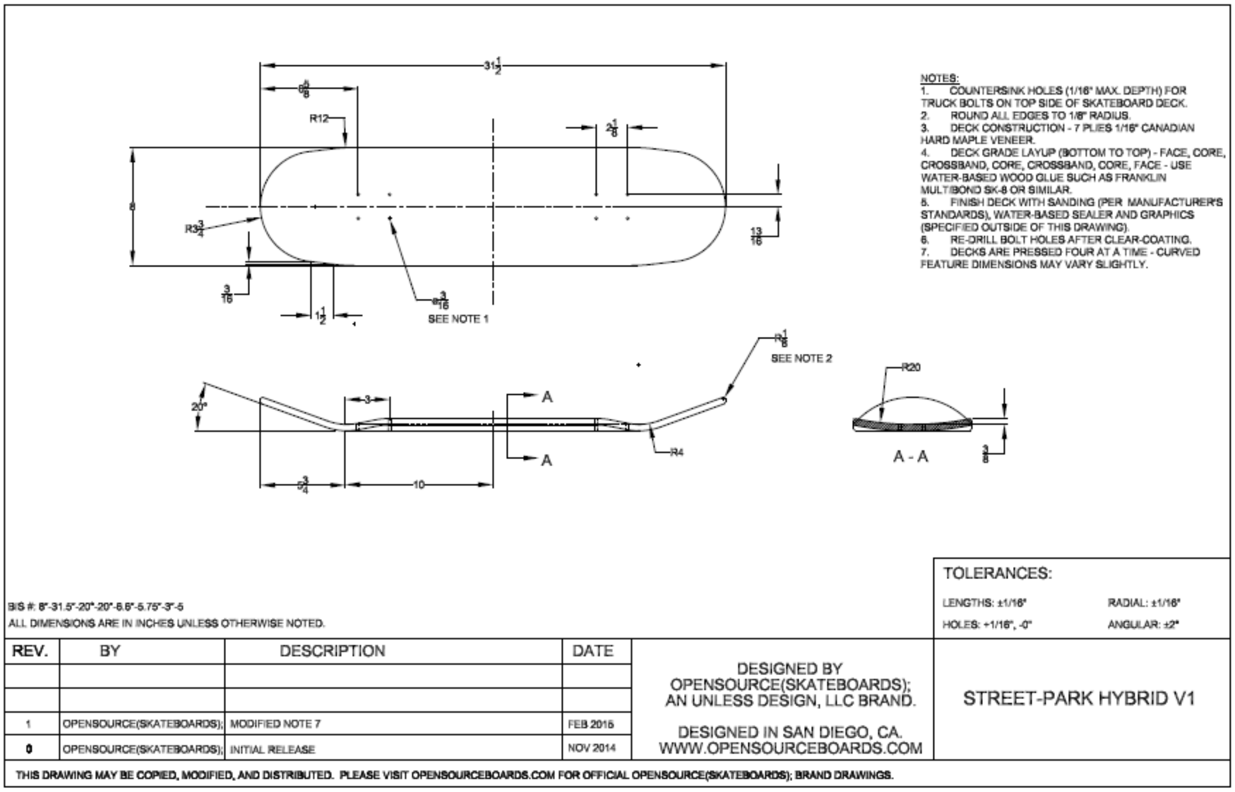
Cross-sectional View:



Notable tools used in cross-sectional view (includes new tools not yet covered):

(1) Arc – for the concave (and may be used to approximate a round kicktail or kicknose)
(2) Hatch – to show the cut (i.e., normally the hatched area is not exposed – this is the "inside" of our skateboard.

Title Block & Border:



Key features:

- Notice how the top and side views are horizontally aligned, and the cross-sectional and side views are vertically aligned (tip: use ORTHO to create straight lines and reference geometry for these views).
- There is a border around all the views.
- There is a "title block", which is broken into rows and columns. Each student's title block must contain:
    - Title
    - Location of design (name of school)
    - Revision history, which has several rows for:
        - Revision number (the initial drawing is revision 0)
        - Designer name ("by")
        - Description of revision
        - Date of revision
- Tolerances – tolerances are the allowable variations in the finished product. For the students' skateboards, if they set a tolerance of ±1/16", that means that for a width specified at 8", they'd be satisfied with an actual width between 7-15/16" and 8-1/16".

Comprehension Demonstration:

1) To make a 200 inch long by 150 inch tall rectangle with the line tool, what are the commands for placing each point (after you've placed the first point)?

   Answer: *@200,0*

   @0,150

   @-200,0

   @0,-150

2) What tool would you use to create a rounded corner?

   Answer: *fillet*

3) What was the biggest challenge you encountered while drawing your board? How did you overcome it?

Lesson 4: Mold-Making & Applied Mathematics

Standards:

Common Core:

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

CCSS.Math.Content.HSG.MG.A.3 *Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).*

Advanced lessons:

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.HSA.CED.A.1: *Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.*

CCSS.Math.Content.HSA.CED.A.4: *Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.*

CCSS.Math.Content.HSA.REI.B.4: *Solve quadratic equations in one variable.*

CCSS.ELA-Literacy.RST.6-8.3: *Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.*

CCSS.ELA-Literacy.RST.9-10.3: *Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.*

Time Estimate: 130 minutes (150 minutes with advanced content)

Learning objectives:

1) Students will use trigonometry and geometry to plan out their mold shape.
2) Students will use hand tools to shape a foam block into a mold.
3) Students will implement basic safety practices when working with tools.

Advanced objectives:

4) *Students will use the quadratic equation and Pythagorean Theorem to transfer their board designs to the foam molds.*

Lesson outcome:

1) Each student will have their own custom, hand-made foam mold for building their skateboard.

Materials:

- Each student's skateboard drawing showing the three perspectives of their board
- High density foam block (1 per student)
- Sharpie marker (1 per student)
- Dust masks (1 per student, plus 1 for teacher)
- Safety glasses/goggles (1 per student, plus 1 for teacher)
- Saw (1 minimum)
- Surform rasp shaver (1 per student)
- Yard stick (1 per 1-2 students)
- Ruler (1 per 1-2 students)
- Quick square (1 per 1-2 students)
- Clear shipping tape
- Vacuum cleaner **(TIP: keep the mold-making lesson in a closed-off area to minimize the spread of foam particles)**
- Optional – wood filler (may be used to patch foam if any students cut too much away)

Reference Materials:

- *Mold Making Checklist* (handout)
- *Side Concave – Teacher's Guide* (teacher's guide)
- *Making a Foam Mold (Overview)* (video link: https://youtu.be/SgYFcxlpvgI, 5 min)
- Concave calculator: http://bit.ly/MoldConcave

Class breakdown

Appx. time:
10 minutes

Learn: The Roarockit Method:

The method students will be using to build their boards is called the "Roarockit method" (Patents 7,132,030 and 2,390,264), in which wood veneers are glued together, placed on a foam mold in a vacuum bag ("Thin Air Press"), and then compressed again the mold by using a pump/vacuum to remove the air from the bag.

Instructor can demonstrate vacuum bagging process without glue using an already made foam mold .

Appx. time:
5 minutes

Watch: Mold Making Overview:

Overview video: https://youtu.be/SgYFcxlpvgI

***Note:** Students **do not** need to print out and trace the kicktail and kicknose as shown in this video. Instead, refer to the process in the *Mold Making Guide*, in which students use trigonometry and straight lines to make their kicktail and kicknose.

Marking the Mold:

Appx. time:
40+ minutes

Use the ***Mold Making Checklist*** to go step-by-step through the mold-marking process with the class, using Sharpies to make the markings. Stress the importance of accurate measurements and markings for creating a straight, high-quality skateboard.

Applied math:

The following concepts can be covered in this process, depending on the abilities of the class:

- Parallel and perpendicular lines
- Midpoints, line segments, and planes
- Trigonometry (used for drawing the kicktail/kicknose – see ***Mold Making Checklist*** for further details)
- ***Advanced, Option 1*:***
  - Use the quadratic equation to mark the concave lines on the sides of the mold (see ***Mold Making Checklist*** for further details)
- ***Advanced, Option 2*:***
  - **Challenge:** Ask students to work together or independently to determine the concave line markings (on the sides of the mold) **without** mentioning the quadratic equation (the goal is to have students determine on their own that the quadratic equation is used to solve the problem). Give students 15 minutes to solve, then review as a class (5 minutes).

Option 1:
+10 minutes

Option 2:
+20 minutes

If neither Option 1 or Option 2 are pursued, use the* **Concave Calculator *Excel spreadsheet to quickly determine the concave line dimensions for each student.*

You can use the ***Mold Example Diagram*** handout as a reference for how a final marked-up mold may look, and to provide suggested dimensions for students.

Mold Shaping:

Appx. time:
75 minutes

Safety:

- **Dust mask** (cutting and shaving foam generates many foam particles)
- **Safety glasses/goggles**

Tips:

- Use caution when working with cutting tools
- Be controlled and calm while using tools
- Communicate clearly with peers
- If something doesn't seem right, ask the instructor for help
- Be self-aware AND aware of your peers and environment

Students will shape their foam molds by using a saw to cut the kicktail/kicknose and using a rasp shaver to shave the rest of the mold down, using the markings they made as guide lines.

All faces will be **flat** (no curved surfaces).

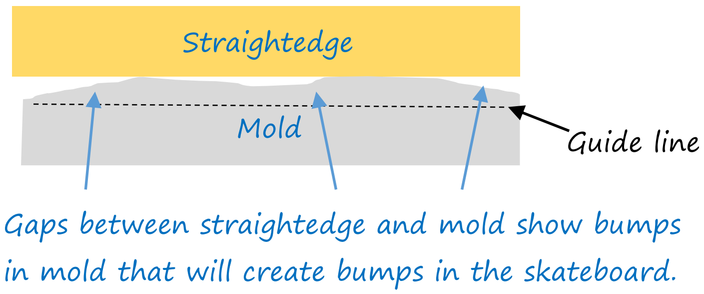
> *Making curved surfaces accurately by hand is very difficult, and the wood will naturally curve around corners.*

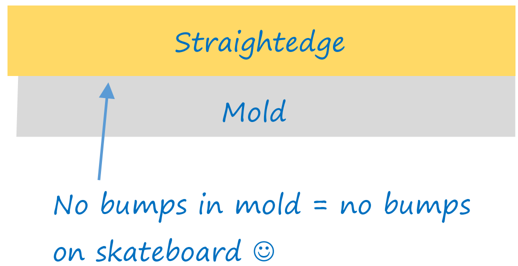
If there are not enough saws, students can get started on shaving the concave of their mold while waiting to cut their kicknose and kicktail.

Once completed, students will use clear shipping **tape to cover the top of their mold**. This needs to be done to <u>prevent the wood from getting glued to the foam</u>.

Tips for Creating a Great Mold:

- Give yourself at least 1/8" of a buffer between where you cut with the saw and your guide line.
- If you start sawing towards your guide line, change direction or start a new cut.
- Hold a straightedge against your mold to check for flatness (remember, if your mold's faces are crooked or bumpy, your board will be crooked or bumpy!)





How to Fix your Mold:

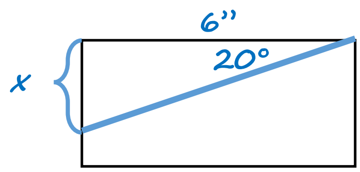
If you shaved a little too much off and have a dip, you can use wood filler (available at Home Depot) to patch and fill in the dip.

Comprehension Demonstration

1) What safety equipment is required for shaving foam?

Answer: Safety glasses and dust masks

2) What is the distance *x* for the following kicktail, if you know the kicktail angle is 20° and the kicktail length is 6”?



Answer: *tan(ϑ) = opposite/adjacent → tan(20°) = x/6 → x = 2.18”*

Lesson 5: Vacuum Forming

Standards:

Common Core: CCSS.ELA-Literacy.RST.6-8.3: *Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.*

CCSS.ELA-Literacy.RST.9-10.3: *Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.*

Time Estimate: 150 minutes (varies with class size)

Learning objectives:

1) Students will understand pressure concepts like absolute pressure, gauge pressure, and atmospheric pressure.
2) Students will calculate the amount of force applied on their skateboard.
3) Students will follow build instructions to vacuum form their boards properly.

Lesson outcome:

1) Each student will glue and vacuum-form their veneers into a molded, uncut skateboard shape.

Materials:

- Each student's mold
- Vacuum bags (1 per student*)
- Breather netting (1 per student)
- Hand pump (1 minimum)
- Set of 7 veneers – 2 face, 3 core, 2 crossband (1 set per student)
- Glue
- Glue roller with high-density/thin nap (1 minimum)
- Smocks (recommended)
- Shop vac / vacuum cleaner (recommended)
- Table covers (recommended)
- Paper towels (recommended)
- Ziploc bag (recommended for storing and reusing naps)
- File, rasp, or sandpaper (recommended)

**The "glue-ups" can be done in stages with less bags. For example, with a class of 10 students, 5 would glue-up the first day, and 5 would glue-up the second day.*

Reference Materials:

- *How Much Force?* (handout)
- Making a Skateboard Explained: The Roarockit Method (video link: https://youtu.be/EFTVzIssoIQ?list=PLbSelZe8CqW8f4S0C8vYMDgASY3WBfi3q)
- *Glue-Up Supplies Checklist* (handout)

Class breakdown

Learn: Pressure:

Appx. time:
15 minutes

Pressure is the amount of force over a specific area. You exert more pressure on the ground when you stand on your toes, but not more force, because your toes have a smaller surface area than your entire feet.

The units of pressure include:

- psi (pounds per square inch)
- mmHg (millimeters of Mercury)
- bar
- atm (atmospheres)
- Pa (Pascals)
- Torr

Pressure (P) is calculated by dividing force (F) by the area (A) that force acts on:

$$\boldsymbol{P = \frac{F}{A}}$$

Absolute pressure is the total pressure (relative to 0 psi).

Gauge pressure is the pressure relative to ambient pressure (if the absolute pressure is 20 psi and the ambient pressure is 15 psi, the gauge pressure is 5 psi).

Exercise: What is the absolute pressure in a car tire if we're at sea level (14.7 psi atmospheric pressure) and the tire pressure says 32 psi?

Answer:

$$P_{atm} + P_g = P_{abs}$$

$$14.7\ psi + 32\ psig = \mathbf{46.7\ psia}$$

As a class, look up the current atmospheric pressure in your city.

Exercise: Students will use the *How Much Force?* handout to calculate the maximum theoretical force applied to their skateboard using the Roarockit method.

Example calculation:

Barometric pressure in San Diego: 29.88 inHg

$$29.88\ inHg \times \frac{0.491154\ psi}{1\ inHg} = 14.7\ psi$$

$$Surface\ area\ of\ veneer\ (A) = 9.5\ in\ \times 34\ in = 323\ in$$

$$P = \frac{F}{A} \quad \rightarrow \quad 14.7\ psi = \frac{F}{323\ in} \quad \rightarrow \quad F = 14.7\ psi\ \times 323\ in = \mathbf{4748.1\ lb}$$

4748.1 lb ≈ 2.4 tons!

Appx. time: 10 minutes

Learn: Materials and Composites:

Skateboard decks are made of two materials:

1) Maple veneers (veneers are thin sheets of wood)
2) Glue

The Wood:

The wood used for skateboards comes from Hard Maple trees – the same trees that provide maple syrup!

Veneers are made by "peeling" a log – the process can be compared to pulling paper towels from a roll.

Watch: Video of log peeling: https://www.youtube.com/watch?v=csm0DTpJOpk

There are three types of veneers used in skateboard decks:

- **Face veneers** – the wood grain runs along the length of the veneer, and the veneers have no defects
- **Core veneers** – like face veneers, except minor defects (such as splits, knots, discoloration) are allowed
- **Crossband** veneers – the wood grain runs along the width of the veneer

Exercise: Why would we need crossband veneers?

Answer: provide strength across width of the deck and resist twisting

A skateboard is a laminar composite – veneers are glued-up in alternating directions of strength to create a composite material with strength in both directions. More specifically, the veneers are laid up symmetrically, as follows:

Face

Core

Crossband

Core

Crossband

Core

Face

A layer of glue between each veneer bonds the veneers together.

Sourcing the wood:

It's important to source materials in ways that are sustainable and environmentally-friendly. There are various management programs that are used to classify the sourcing of wood:

- FSC (Forest Stewardship Council) certification: https://us.fsc.org/en-us
- SFI (Sustainable Forestry Initiative) certification: http://www.sfiprogram.org/
- Government programs (e.g., Quebec's Sustainable Forest Development Act http://legisquebec.gouv.qc.ca/en/ShowDoc/cs/A-18.1)

The Glue:

Most skateboards are made with either a water-based glue (what the students will use) or epoxy resin.

The water-based glue is easier to clean up and nontoxic. It tends to be more flexible than epoxy resin, which can be a benefit or drawback, depending on how the skateboard is meant to be used. Wood glue is also less expensive than epoxy resin.

The combination of strategically-arranged veneers and glue results in a final composite material that has the best properties of both the wood and glue (it's stronger than its individual components).

Appx. time:
20 minutes

Glue-Up Review:

Watch: Making a Skateboard Explained: The Roarockit Method (video playlist):

https://youtu.be/EFTVzIssoIQ?list=PLbSelZe8CqW8f4S0C8vYMDgASY3WBfi3q

Prepping the Veneer: ~5 minutes

The "Dry Run": ~4 minutes

Gluing: ~3.5 minutes

The Glue-Up: ~5 minutes

Recommendation: Prep the veneers by using a file, rasp, or sandpaper to dull any sharp corners. This may help prevent any damage to the vacuum bags.

Review the "Glue-up Tips" and "Glue-up Process", outlined below.

Appx. time:
12 minutes
per student

Glue-Up:

It's generally recommended that the teacher pours the glue for the students, as it's easy to pour too little or too much – after several boards, the teacher will have a good feel for what is the right amount. Students not *gluing their boards will print, assemble, and cut their paper templates (per Lesson 3). They can also start to brainstorm and sketch their ideas for their board's artwork.*

For larger classes with a time constraint, students can split into glue-up teams and designate the glue-pourer for each build.

Cover the table to protect it from any glue spills.

***Note – glue will not come out of clothing! Have students wear old clothes or smocks/aprons to prevent getting glue on clothes.**

Arrange the 7 veneers on the table in the proper order.

Set up the bag, breather netting, vacuum (if using), hand pump, and glue roller.

Each student will do a "dry run" first, without any glue.

Once the unglued veneers are vacuum-sealed, check the bag for any leaks.

Exercise: What was challenging about the dry run? How can you overcome those challenges during the glue-up?

Remove dry-run veneers from bag, set up the veneers on the table. Flip the first veneer over so that it is next to the rest of the veneers.

Student and glue-pourer confirm they are both ready, and the glue-up begins.

Glue-up Tips

- **Once you start, you can't stop!** The glue has an open time of 10 minutes, which means it needs to be in the bag and sealed in under 10 minutes. Students will need to work fast.
- **Be careful!** Veneers are fragile, and when rolling the glue on quickly, it can be easy to "catch" a veneer and snap it. The best way to roll is with large, gentle, controlled strokes.
- **No pools or streaks!** Any small pools of glue or streak marks can cause glue bubbles in the skateboard. Some students may have seen videos of skateboards being made in factories, where hydraulic presses squeeze two molds together, and the excess glue squeezes out; in a vacuum bag, you can't squeeze out the excess since there's nowhere for it to go.
- **Keep the coat even!** An uneven coat of glue will cause the board to warp once it comes out of the bag.
- **No bare spots!** Too little glue, and the skateboard will delaminate, which means that it will come apart between layers of veneers.
- **Be respectful of the tools!** Like the veneers, the vacuum bags and hand pumps are not indestructible – be gentle when placing the board in the bag, be gentle around the valve, and be gentle while pumping. Things can break if not treated with care.
- **Have a team!** Have students work together to prevent the vacuum bag from "creeping" under the veneers as the air is removed. The goal is to make sure the veneers rest flat against the mold, with none of the vinyl bag getting in between the board and the mold.

Glue-up Process

1) Once the student and glue pourer are ready, the glue pourer will pour glue onto the single veneer and the top veneer in the stack.
2) The student will roll the glue on each veneer.
3) Once each veneer has a thin, even coat (a proper coat looks like **a thin coat of paint**), flip the veneer from the stack onto the single veneer, so that **both glued sides are touching**. Make sure the veneers are **aligned** when stacked! These cannot be adjusted later, as the glue will have started to form a bond.
4) Repeat steps 1-3 until there are no veneers left to stack, and remember not to pour glue on the top of the last veneer.
5) Place the veneers in the bag, **centering them on the mold**. Place the breather netting on top of the board and directly under the valve. The breather netting prevents the valve from sticking to the board, and creates air channels to help pull all the air out of the bag.
6) Seal the bag.
7) OPTIONAL – VACUUM ONLY: Remove the valve cap and connect the hose of the vacuum cleaner to the valve opening. Turn on the vacuum and let it suck the air until the board starts to compress. Quickly place the valve cap back on the opening.
8) Use the hand pump to pump the remaining air out of the bag. Have the other students help prevent the bag from creeping under the board.
9) The pumping can stop once the board is pressed tightly against the mold and the pump is difficult to pump. Listen for any leaks by listening close to the valve and close to the seal.
10) If moving the bag, be gentle and take care not to knock the valve loose.
11) Check the bag in 5 minutes, then again in 10-15 minutes, to make sure it's holding a seal.
12) Leave the boards in the bag for the glue to set for at least 16 hours (a minimum of 24 is ideal, if possible).

Congratulations! This is a difficult process, and each sealed bag is an opportunity to celebrate with the students.

Comprehension Demonstration

1) How much force (in tons) would be applied to longboard veneers (12" x 48") when vacuum forming at sea level (14.7 psi)? Assume there's a perfect vacuum (0 psia) inside the bag. (Hint: 2000 lb = 1 ton)

Answer:

Surface area = 12 in x 48 in = 576 in^2

P = F/A → *F = P x A = 14.7 lb/in*^{2} *x 576 in*^{2} *= 8,467.2 lb ≈ 4.2 tons*

2) What are some other things you can make with vacuum-forming?

Lesson 6: Woodworking

Standards:

Common Core: CCSS.ELA-Literacy.RST.6-8.3: *Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.*

CCSS.ELA-Literacy.RST.9-10.3: *Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.*

Time Estimate: 150 minutes (varies with class size)

Learning objectives:

1) Students will learn how to use power tools to shape wood.
2) Students will learn the basic safety of power tool operation.
3) Students will learn how to templates are used in manual fabrication processes.
4) Students will learn why wood needs to be sealed.

Lesson outcome:

1) Each student will cut and sand their board into their custom shape.
2) Each student will drill the bolt holes for their trucks.
3) Each student will seal their board.

Materials:

- Safety glasses for each student
- Dust mask for each student
- Each student's uncut board
- Each student's template from Lesson 3
- Pencils and erasers
- Tape
- Wheelbase template
- Jigsaw or bandsaw
- Drill
- 13/64" drill bit
- 1/8" drill bit
- Belt sander (or rasp shavers)
- Random orbital sander (or rasp shavers)
- Yard sticks and rulers
- Sandpaper (150 grit and 220 grit recommended)
- Towel/cloth
- Foam brushes
- Sealer
- Table cloth(s)

- Props/stands for boards (when sealing)
- Rubber gloves
- Hammer & nail

Reference Materials:

- *Finishing Guide* (handout)

Class breakdown

Appx. time:
15 minutes

Learn: The Shaping Process:

Cutting out the skateboard: https://youtu.be/HHqpmVHOh_U *(note: while the template is laser-cut in this video, the process of applying the template remains the same; see the Finishing Guide handout for more instructions.)*

Build: Work Stations

Appx. time:
135 minutes

Safety:

- **Safety glasses/goggles**
- **Dust mask**
- **Closed-toe shoes**
- **No jewelry or loose-fitting clothes**
- **Tie back long hair**

Tips:

- Use caution when working with tools
- Be controlled and calm while using tools
- Communicate clearly with peers
- If something doesn't seem right, ask the instructor for help
- Be self-aware AND aware of your peers and environment

Once students have traced their boards, break up the class into stations:

- Cutting station: Students (or teacher) will use the available cutting tools (jigsaw, bandsaw, etc.) to cut around their tracing, staying about 1/8" away from their outline. Use scraps or end of board to do a test cut.

- For sharp bends, do relief cuts (instead of cutting along the curve, cut a series of straight lines around the curved part of the board – the corners can be sanded later).
- Instructor must learn to use cutting tools beforehand and must provide detailed instructions to students with direct supervision.

- <u>Drilling station:</u> Students will use a template to mark the wheelbase of their skateboard.
  - Once marked, use a hammer and nail to make a slight indentation on their markings. (This makes it easier to position the drill bit in the correct location).
  - Next, use a drill to first drill a pilot hole, using the 1/8" drill bit. A **pilot hole** is a small hole that prevents damaging the wood by trying to make too big a hole at once.
  - Once each pilot hole is drilled, change the bit to the 13/64" diameter bit for the final holes. This hole size is slightly larger than the 3/16" diameter bolts so that the bolts easily fit in, and to account for any sealer that may seep into the hole later and tighten the clearance. (A 3/16" bit may be used, but bolts may need to be tapped lightly into the holes to fit.) If available, a countersink bit may also be used to countersink the holes on the top side of the deck.

- <u>Sanding station(s):</u> There may be multiple sanding stations, which consist of the sanding tools available (belt sanders, random orbital sanders, rasps, sandpaper, etc.) Students will start with low-grit sanding (40-80 grit), then 150 grit, and end with 220 grit sanding.
  - The **grit** is a measure of how fine or coarse the sandpaper is – the lower the grit, the coarser the sandpaper, and the faster it removes material (but the rougher the surface).
  - Students can sand the top and bottom of their boards <u>even if they have not yet cut their board</u>. If they haven't yet drilled, they can sand the entire board, then come back to sand around the holes once they've drilled them.

- <u>Sealing station:</u> (Only to be done once the student is done at all other stations.) Students will use a water-based sealer to protect the wood from moisture damage. First, students will wipe down their sanded boards with a towel that has been lightly dampened with water. This removes any dust. Once their board has dried off from the towel (about a minute), prop the board up on some scraps, minimizing the contact area of the board with the scraps. The student can use a foam brush to brush on the sealer - wearing gloves is recommended. Further instructions on sealing is contained on the sealer can.
  - For efficiency, it's recommended to have students first coat the top sides of their boards, then flip the board to coat the sides and bottom. The board will be wet on both sides, but will not stick to the props if the contact area has been minimized. Do the top of the board first so that if there are any marks from the props, they get covered by grip tape, which may be later applied to the completed board.*

**Note – if using a laser cutter to engrave designs onto the skateboards, do the engraving before sealing.*

<u>Troubleshooting Guide:</u>

Delamination: Delamination ("delam") is when the board comes apart between layers of veneers. This is caused by not enough glue, or not pressing the board before the glue set. To fix delam, use a small, thin object to rub glue into the split. Then, use clamps (or the vacuum bag, if no clamps are available) to clamp the separated veneers together while the glue dries.

Bubbles: Bubbles are caused by too much glue and uneven application of the glue (streaks of glue were left on the veneers). To fix bubbles, simply sand the bubbles flat. If an air gap is exposed, use a mixture of wood glue and saw dust to patch the gap.

Warping: Warping is when the board twists after it is out of the bag, and is caused by using too much glue. To fix warping, the board will need to be clamped so that it is twisted in the *opposite* direction (about the same amount of twist in the warp), and then heated using a heat gun. Let the board cool down while still clamped. Once cooled, remove the board and check that it relaxes into the straightened position.

Trucks don't fit: If the trucks don't fit on the board, it's because the holes are not properly aligned. Try to get as many bolts through both the deck and trucks as you can, while making sure the trucks are installed straight. Mark where the new holes need to be drilled, then re-drill the holes. If the misaligned holes are very close to the required positions, use a larger drill bit to widen the hole, and angle the bit towards the required position.

Comprehension Demonstration:

1) What safety equipment is required for working with the power tools we used?

Answer: Safety glasses and dust masks.

2) Which of the following grits would you use to finish your board? 60 grit, 150 grit, 220 grit

Answer: 220 grit.

3) What was the hardest part about finishing your board? What did you do to make it easier (or how can it be made easier next time)?

Lesson 7: Art and Reflections

Time Estimate: 100-200 minutes

Learning objectives:

1) Students will express their creativity through custom artwork.

Lesson outcome:

1) Students will have their finished boards with their own custom graphics.

Materials:

- Each student's sealed board
- Pencils and erasers
- Paints and/or Sharpie markers
- Foam brushes
- Table cloth(s)
- Props for boards
- Smocks
- Paper sketches already created
- Sealer (optional)

Class breakdown

Appx. time: 90 minutes

Applying Graphics:

Students will use paints or Sharpie markers to draw and customize the look of their boards. They can use pencils to sketch the basic graphic on their boards.

If possible, students can apply a final layer of sealer over their graphic **once the paint is fully dry** (check the instructions on the paint, and seal a test piece first, to make sure the paint doesn't smear when coated). This additional layer would make the graphic more glossy, and is not required.

Advanced Option: Extended Time:

Appx. time: 100 minutes

The instructor may allow more time to be spent on creating graphics, and may use this time as an extension or to cover specific customization techniques.

Appx. time:
10 minutes

Reflections:

Once all students have completed their graphic, reflect on the entire process. As a group, discuss:

- What was your favorite part of the process?
- What was your least favorite part?
- What was the biggest challenge you had, and how did you overcome it?
- How was working with your classmates helpful?
- What's one new skill you have, and how do you hope to use it again?
- What are some other things you might be able to make now?
- If you could make another board, what would you change? (Either about the process or your board.)

Congratulations!

The finished boards can be taken home or used in an art show at school to show off the hard work and accomplishments of the students. This can also be a fundraising opportunity for the next board-building workshop.

Finally, remember to **be safe!** Wear a helmet, and always be mindful of your environment – look out for cars and people.

Parts (trucks, wheels, etc.) from Fun Box Distribution can be ordered through Open Source Skateboards at a discount – create a list of parts from www.funboxdist.com and send that list (along with quantity) to contact@opensourceboards.com to get the discounted pricing.

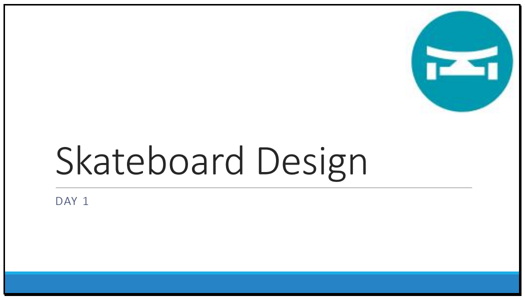
APPENDIX

Additional resources for running a skateboard building program.

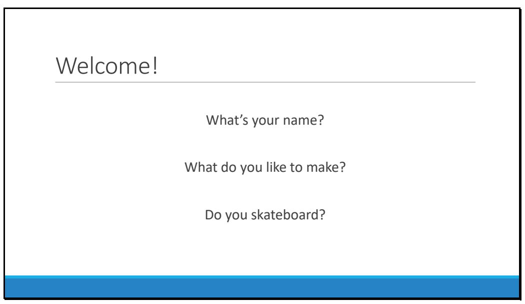
Lesson 1: lesson1-slides.pptx

Sample PowerPoint slides

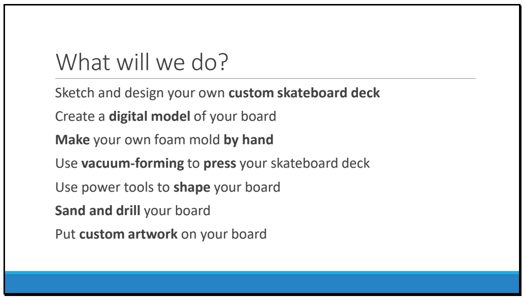
Slide 1



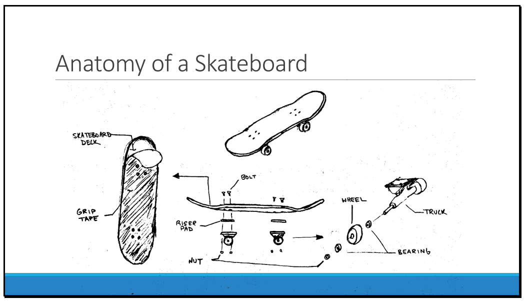
Slide 2



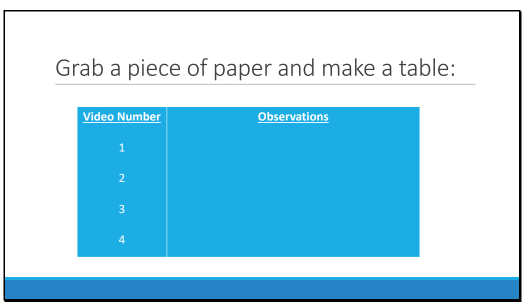
Slide 3



Slide 4



Slide 5



Slide 6

Observations

Write down what you notice about the **skateboard** and **type of skateboarding** in each video:

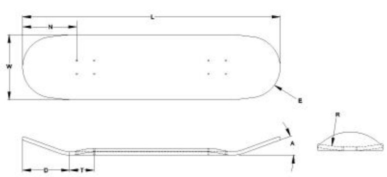
Video 1: https://www.youtube.com/watch?v=og7x7W8qSe0
Video 2: https://www.youtube.com/watch?v=-lHSvsB46Og
Video 3: https://www.youtube.com/watch?v=OW-J2pQrlsw
Video 4: https://www.youtube.com/watch?v=TVW0VlyjWOE

Slide 7

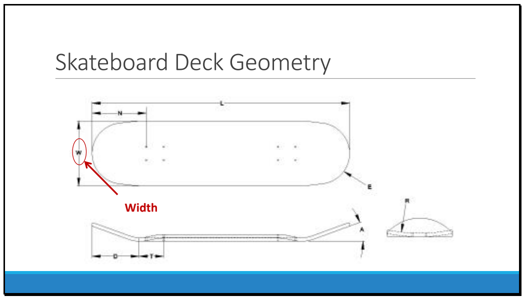
What did you notice???

Slide 8

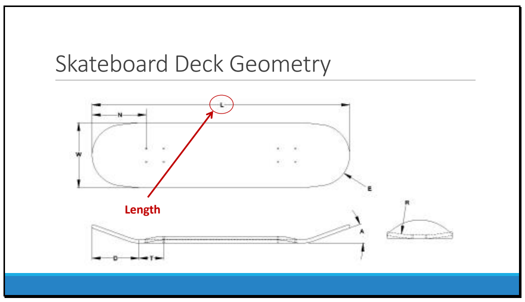
Skateboard Deck Geometry



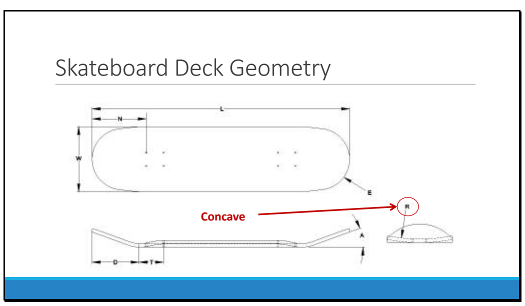
Slide 9



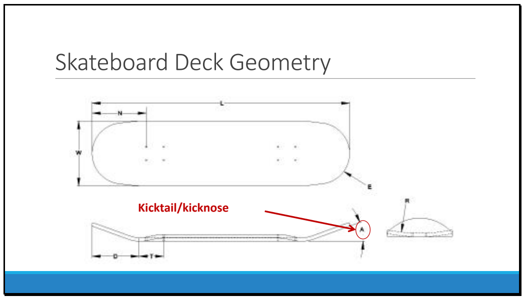
Slide 10



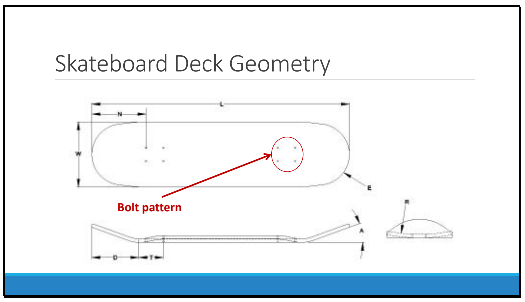
Slide 11



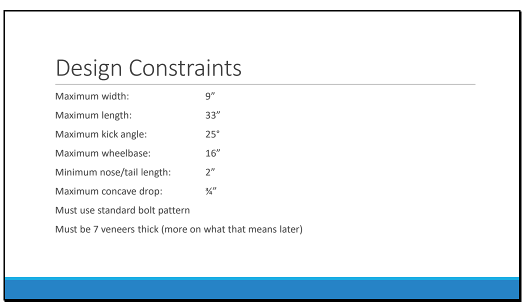
Slide 12



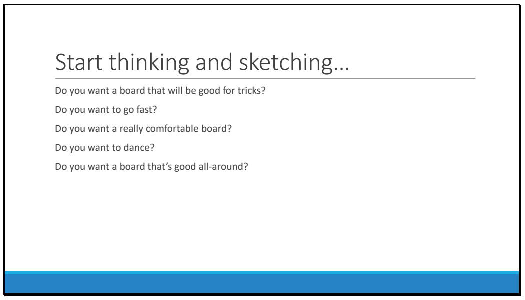
Slide 13



Slide 14



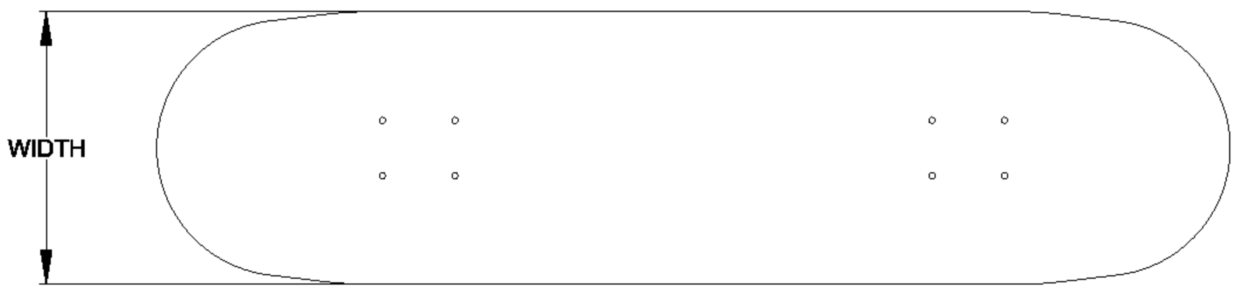
Slide 15


Start thinking and sketching…
Do you want a board that will be good for tricks?
Do you want to go fast?
Do you want a really comfortable board?
Do you want to dance?
Do you want a board that's good all-around?

Lesson 2: Skateboard Design Guide

A guide (but not rules) for designing skateboard shapes

Width:

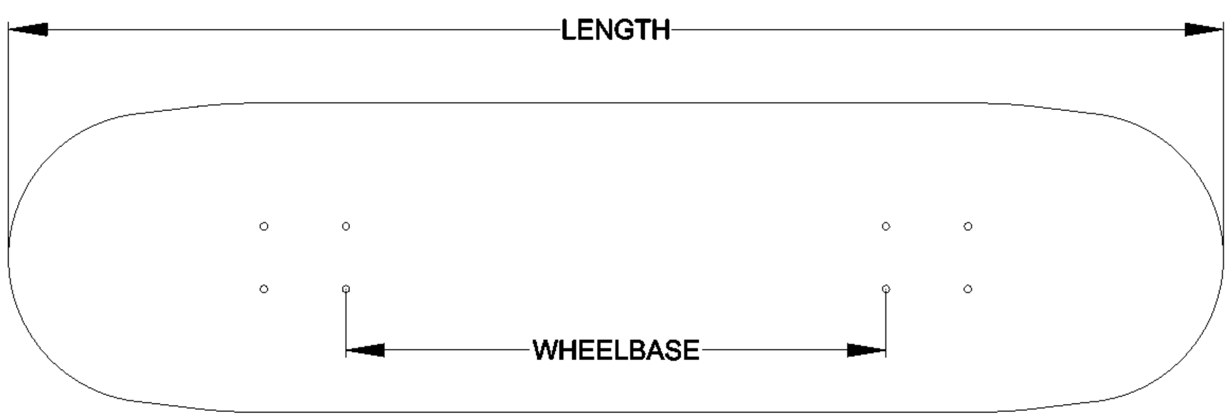


Typically 7.75" – 8.5"

Wider = more stability (easier to keep your balance)

Thinner = more control (lighter and easier to maneuver)

Length & Wheelbase:

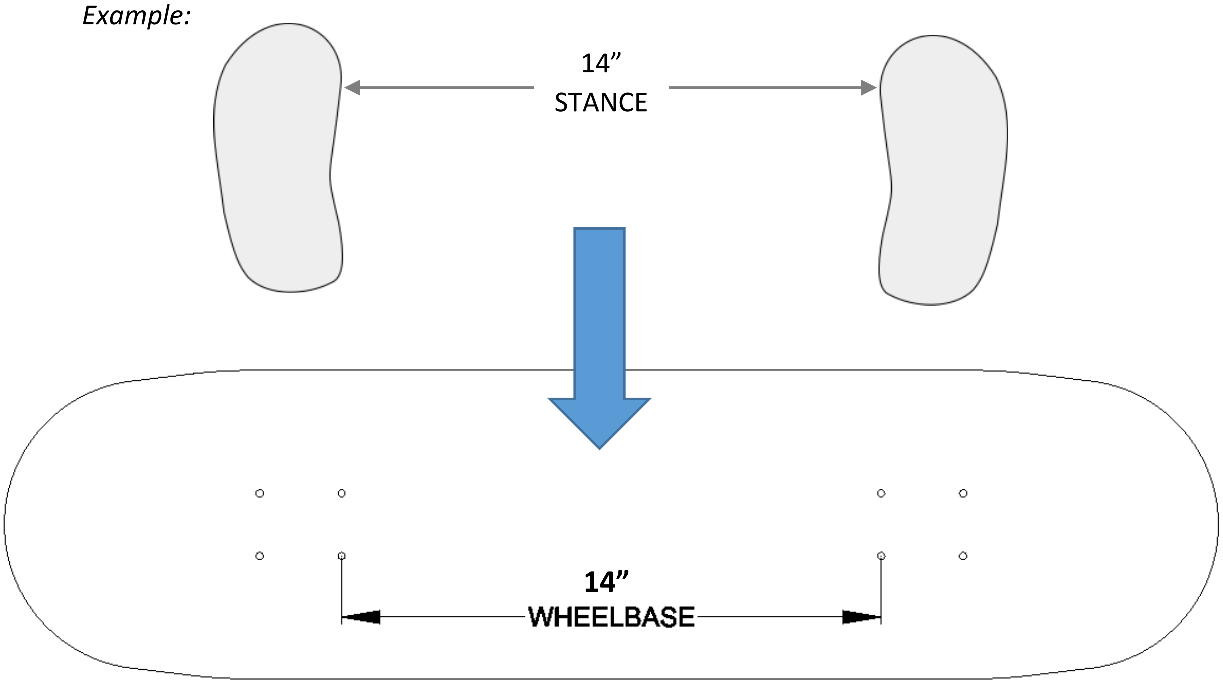


Length: typically 31" – 33"

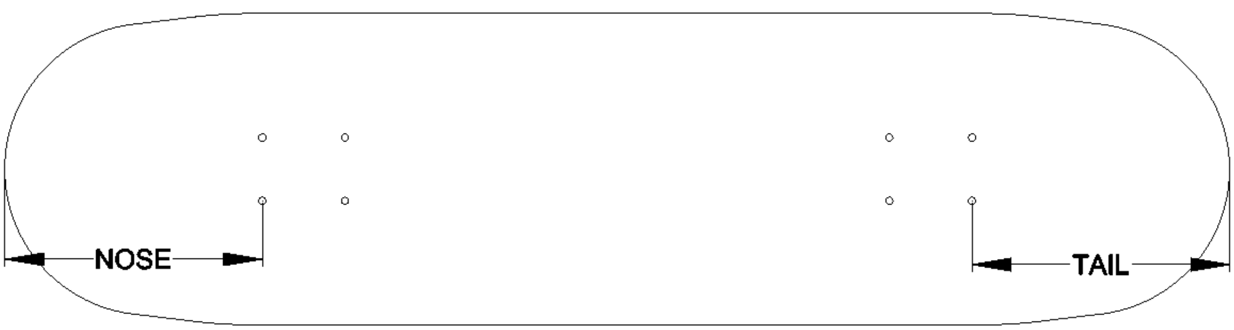
Wheelbase: typically 13.5" – 15"

Wheelbase can be determined by your **stance width** (how far apart your feet are while standing on the board):

Example:



Nose Length & Tail Length:

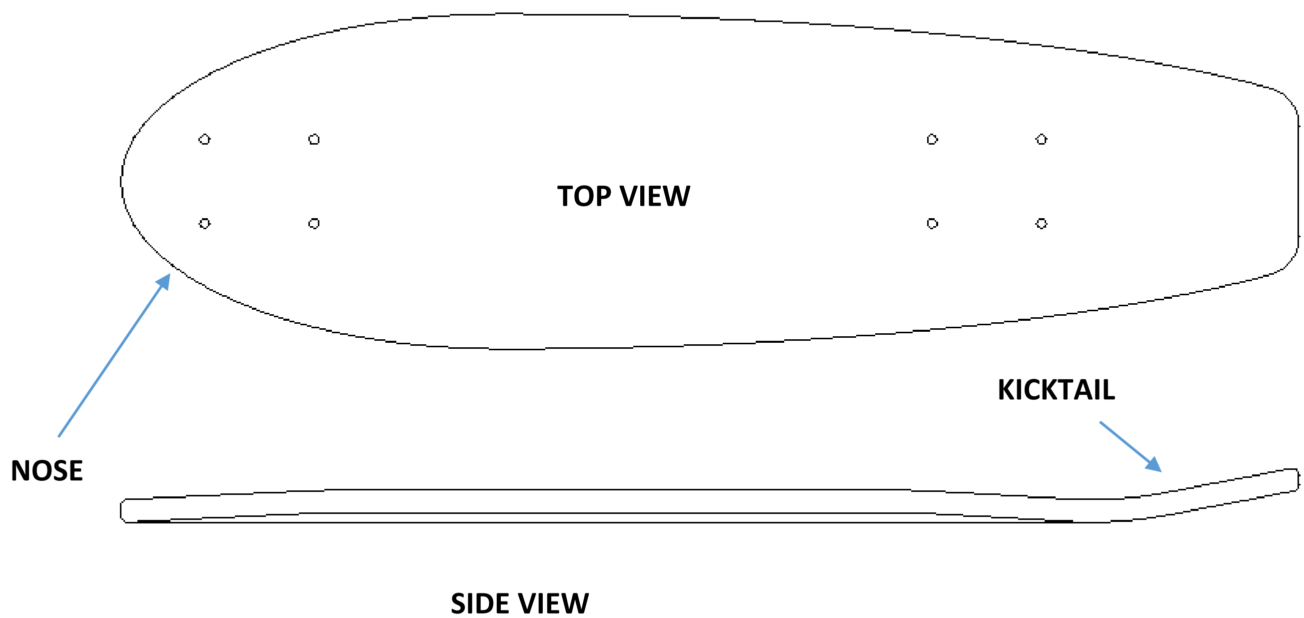


Typically 6” – 7”

Nose and tail lengths don’t have to be the same.

*If your board doesn't have a **kicknose**, your wheelbase may be almost as long as your length, with a very small nose length.

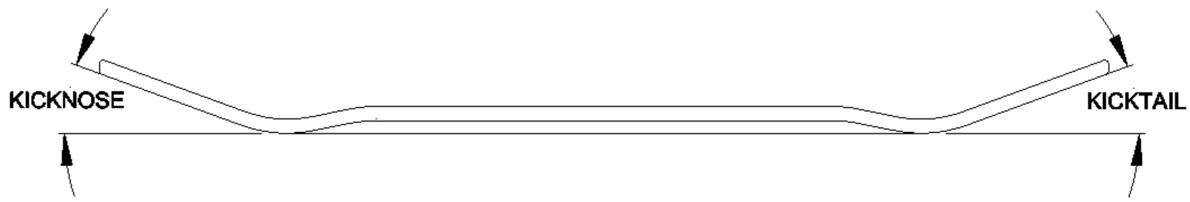
Example (mini-cruiser):



Bolt Pattern

The bolt pattern dimensions are almost always the same – the dimensions shown are standard for skateboard trucks. **If these holes are not exactly the dimensions as shown, your trucks will not mount to your skateboard!**

Kicktail & Kicknose

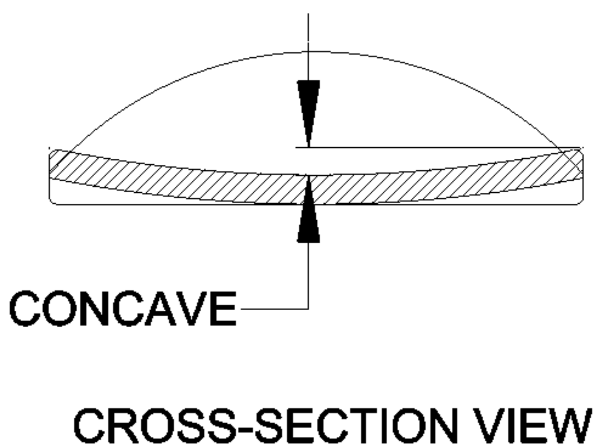


Typically 16° – 21°

Steeper angle = more leverage with ollies and turning

Mellower angle = quicker “pop” with ollies

Concave



Typically 1/8” – 1/2”

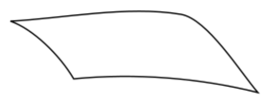
Steeper concave = stiffer, provides “pockets” for feet

Mellower concave = more flexible, provides “platform” for footwork

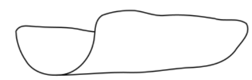
Try it yourself!

Take a piece of paper, and hold it straight out. Does it stay flat?

Now take that same piece and curve it while holding it straight out. Do you notice a difference in the "stiffness" of the paper?



Flat paper (no concave)



Curved paper (concave)

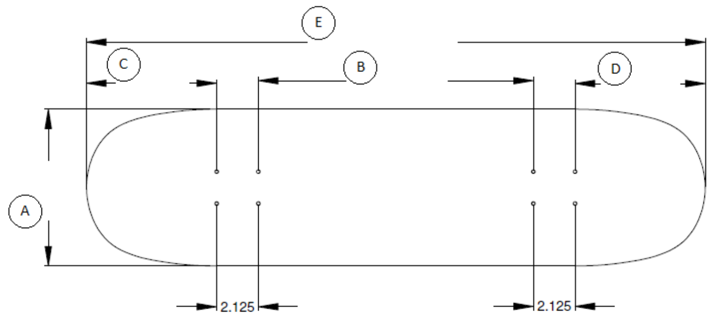
Brainstorming

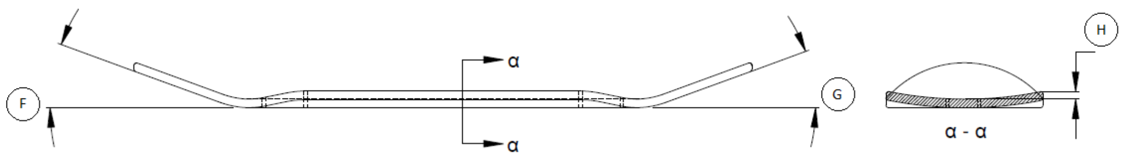
Search around the internet, and look at your skateboards and friends' skateboards for more ideas for board shapes and sizes. Make notes or take screen shots of the features you like.

Lesson 2: Skateboard Dimension Template

Fill in the blanks to identify the key geometry of your skateboard design

If you are making a popsicle-style skateboard, fill out the specifications for the skateboard below:





(A) Width: ___________

(B) Wheelbase: ___________

(C) Tail Length: ___________

(D) Nose Length: ___________

(E) Length: ___________

(F) Kicktail Angle: ___________

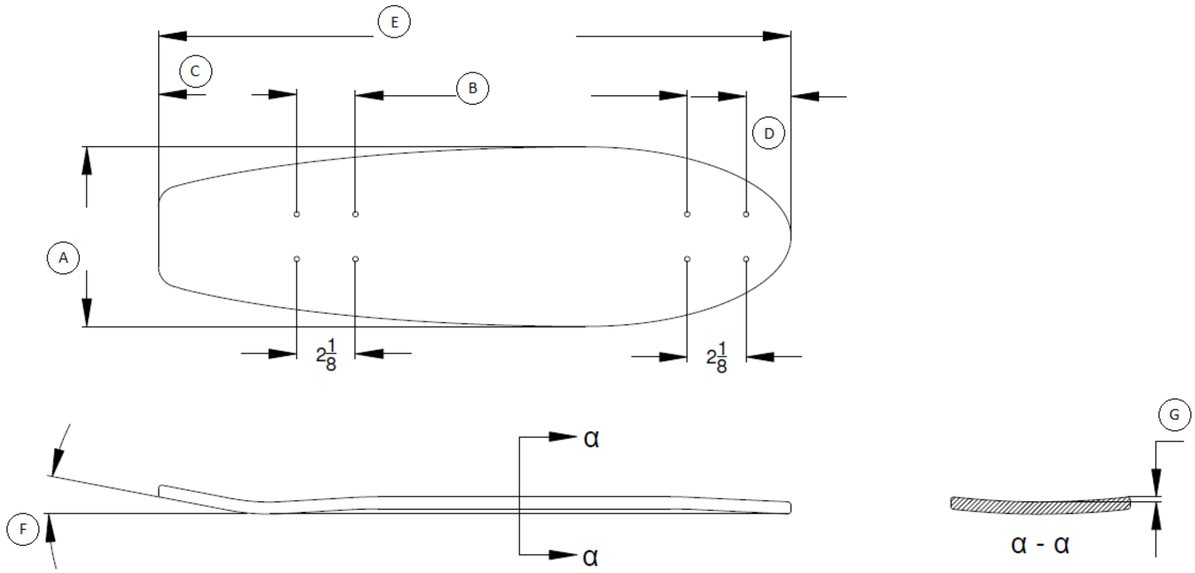
(G) Kicknose Angle: ___________

(H) Concave: ___________

Remember: Length (E) is equal to the sum of the nose length (D), tail length (C), wheelbase (B), and two bolt pattern lengths (2.125 x 2):

$$E = C + 2.125 + B + 2.125 + D$$

If you are making a cruiser-style skateboard, fill out the specifications for the skateboard below:



(A) Width: ___________

(B) Wheelbase: ___________

(C) Tail Length: ___________

(D) Nose Length: ___________

(E) Length: ___________

(F) Kicktail Angle: ___________

(G) Concave: ___________

Remember: Length (E) is equal to the sum of the nose length (D), tail length (C), wheelbase (B), and two bolt pattern lengths (2.125 x 2):

$$E = C + 2.125 + B + 2.125 + D$$

Lesson 3: DraftSight Cheat Sheet

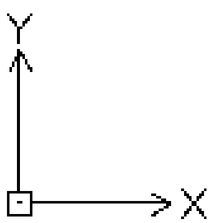
Reference for using DraftSight Free

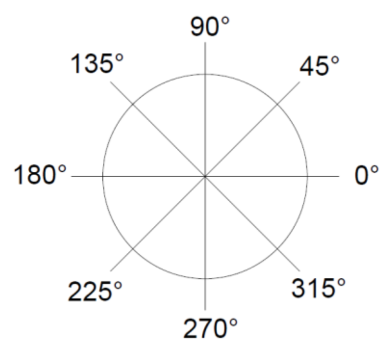
This cheat sheet is meant as a basic reference for using DraftSight Free. Additional support can be found clicking the "Help" tab in DraftSight and selecting "Help" (also accessed by typing HELP and pressing ENTER on your keyboard while in DraftSight).

DRAWING WITH COORDINATES:

Type	Syntax	Example	What it does
Relative coordinates	@x-distance,y-distance	@3,-2.5	Next point is right 3 units, down 2.5 units from previous point
Absolute coordinates	x-distance,y-distance	3,2.5	Next point is AT point 3,2 in the work space
Relative polar coordinates	@distance<angle	@5<165	Next point is 5 units from previous point at 165°

COORDINATE SYSTEMS:





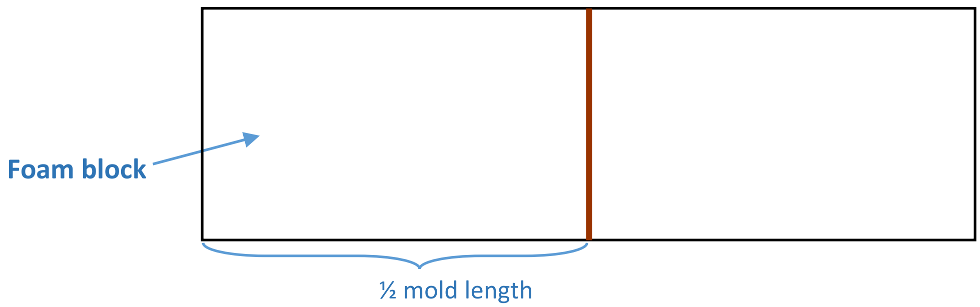
SHORTCODES *(Type the code on your keyboard, then hit ENTER)*

Code	Tool	What it does
L	line segment	Create a line segment
DELETE	delete	Delete object
U	undo	Undo last action
COPY	copy	Make a copy of object
M	move	Move object
FILLET	fillet	Round corners
MIRROR	mirror	Create mirror image of object along a line

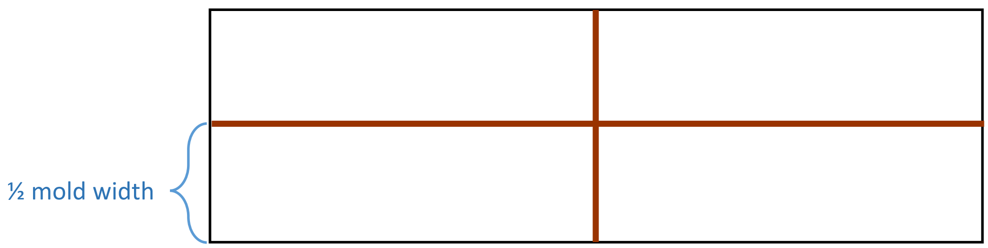
Lesson 4: Mold Making Checklist

A guide for building custom molds together as a class

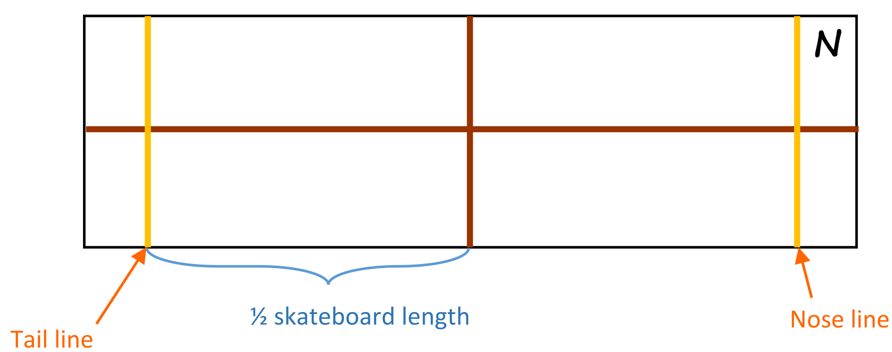
☐ Mark a point half way across the **short** ends of the foam, and connect the points using a straightedge to create a **centerline**.



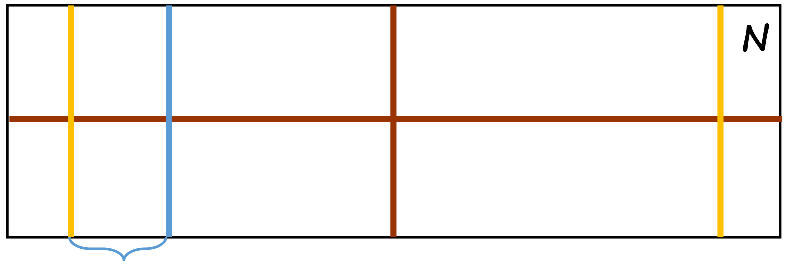
☐ Mark a point half way across the **long** ends of the foam, and connect the points using a yard stick to create a **centerline**.



☐ Draw two lines to represent the length of your skateboard – each line will be **one half** of your skateboard length from the width-wise **centerline**. **Label the nose of your skateboard by writing "N" at the front.**

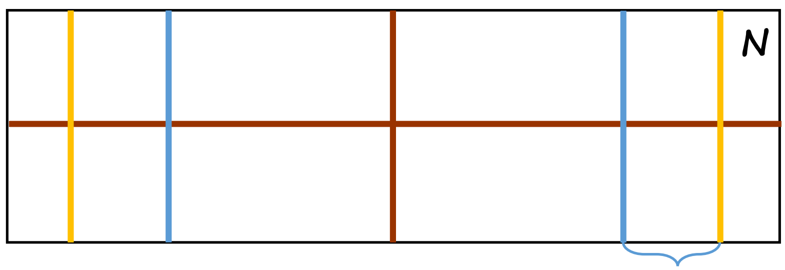


☐ Draw a **kicktail** line – this distance is your **tail length – 1.5”**.



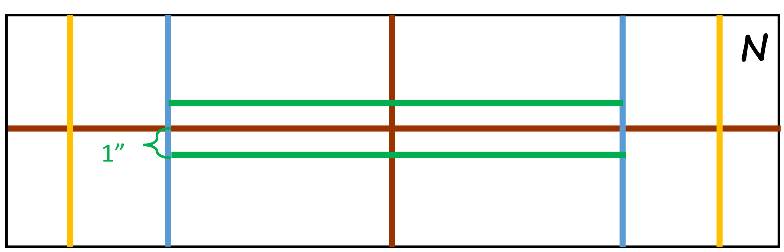
Tail length – 1.5”
(e.g., if your tail length is 7”, the kicktail line will be marked 5.5” from your tail line)

☐ Draw a **kicknose** line – this distance is your **nose length – 1.5”**.

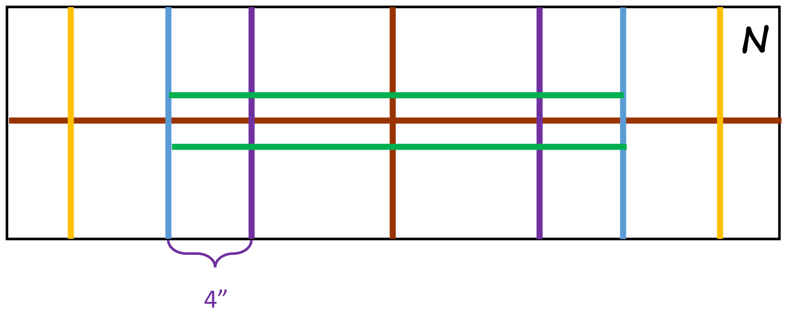


Nose length – 1.5”

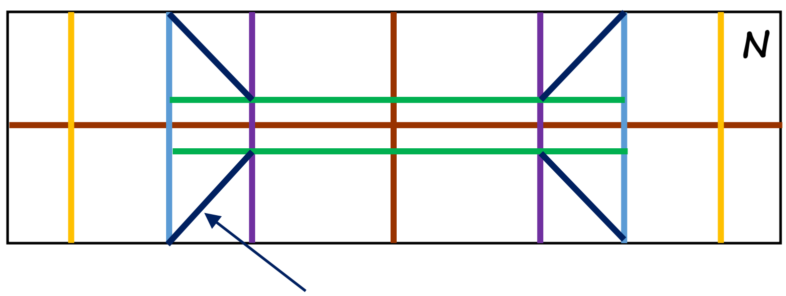
☐ Draw two lines for your **concave** that are 1 inch from the length-wise **centerline**, on both sides of the **centerline**. Start at the kicktail line and end at the kicknose line.



☐ Draw **transition distance** lines 4 inches from the **kicktail** line and **kicknose** line, towards the middle of the block.

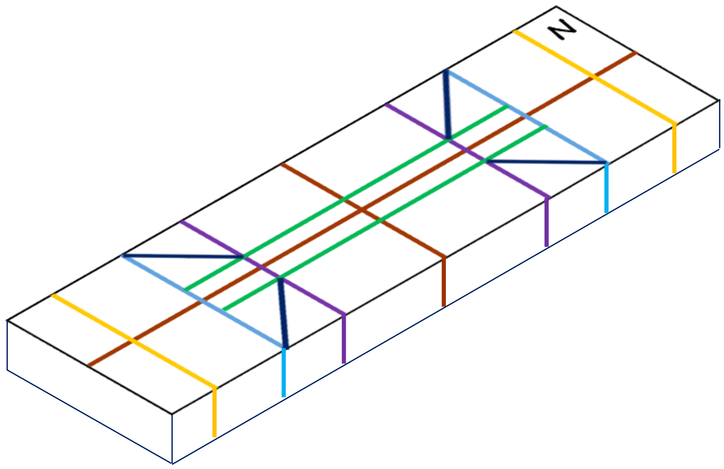


☐ Draw four lines **connecting** the ends of the **kicktail** line(s) to the intersections of the **concave** lines and **transition** lines.

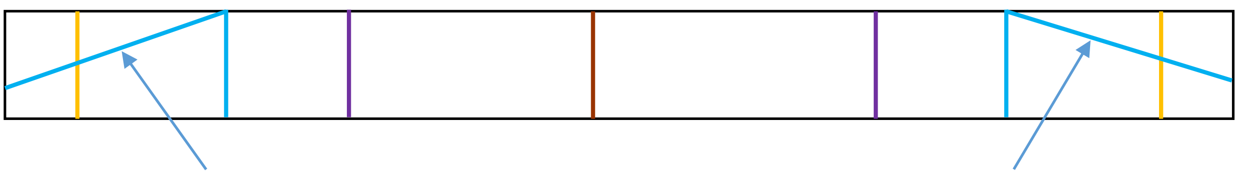


Great! You finished the top markings on your mold. You'll mark the sides next.

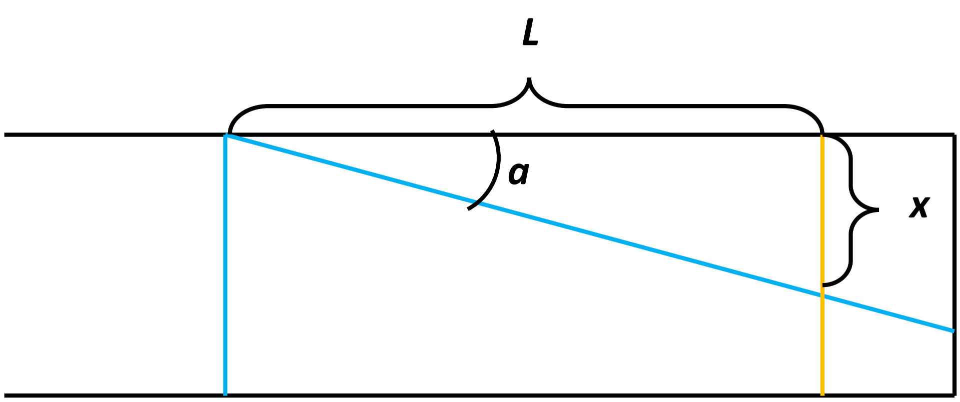
☐ **Extend** the width-wise lines down the long sides of the foam, **on both sides**.



☐ Draw your **kicktail** from the **kicktail** lines.



To do this, you'll need to know the distance, ***x***, shown below. We can use trigonometry to calculate ***x***:



Fill out the info for your board's kicknose and kicktail based on the previous diagram:

Nose:

L = ____________ inches *(nose length – 1.5")*

a = ____________ degrees *(defined on your board dimension template)*

$$\tan(a) = \frac{x}{L}$$

$$x = \_\_\_\_\_\_\_\_\_ \times \tan(\_\_\_\_\_\_\_\_\_) = \_\_\_\_\_\_\_\_\_\_\_ \text{ inches}$$

Tail:

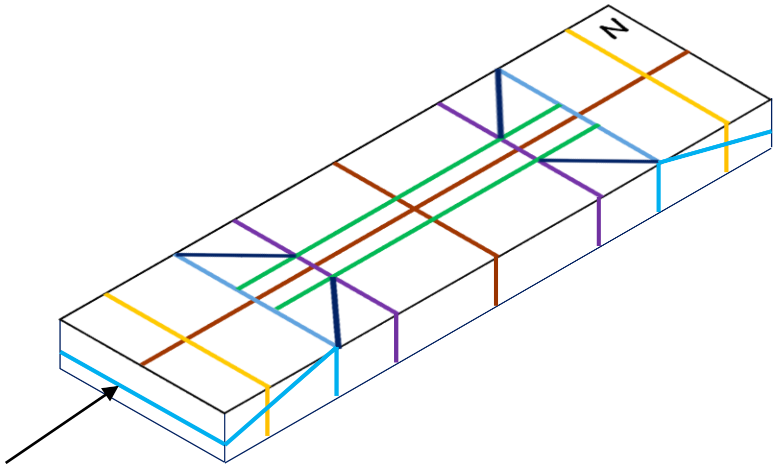
L = ____________ inches *(nose length – 1.5")*

a = ____________ degrees *(defined on your board dimension template)*

$$\tan(a) = \frac{x}{L}$$

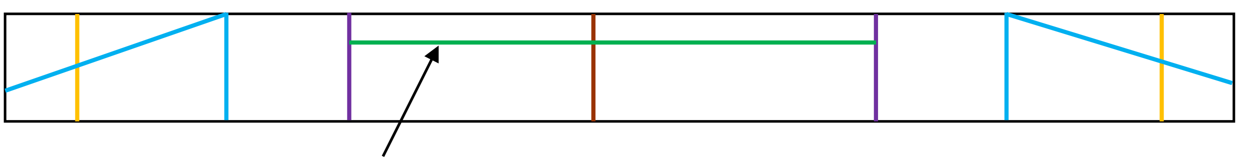
$$x = \_\_\_\_\_\_\_\_\_ \times \tan(\_\_\_\_\_\_\_\_\_) = \_\_\_\_\_\_\_\_\_\_\_ \text{ inches}$$

☐ Draw **horizontal lines** on the short sides of your mold connecting the ends of the **kicktail** lines.

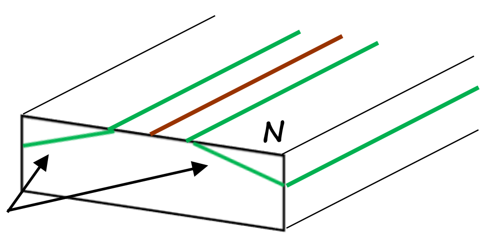


☐ Determine how far down you want to mark the **side concave lines**, then draw them between the **transition** lines on both sides of your mold.

Wait for instructions from your instructor on how to mark these lines.

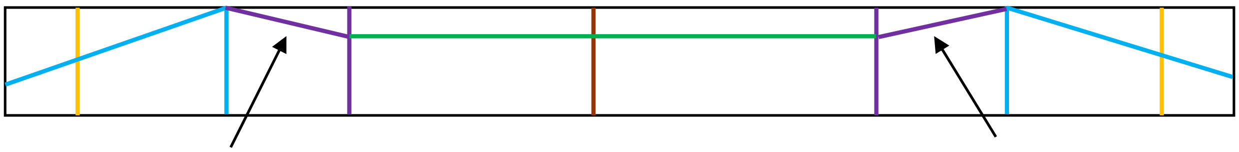


☐ ONLY if you are making a single-kick skateboard (kicktail only), connect the **side concave lines** to the **top concave lines** on the nose side of the foam:



`

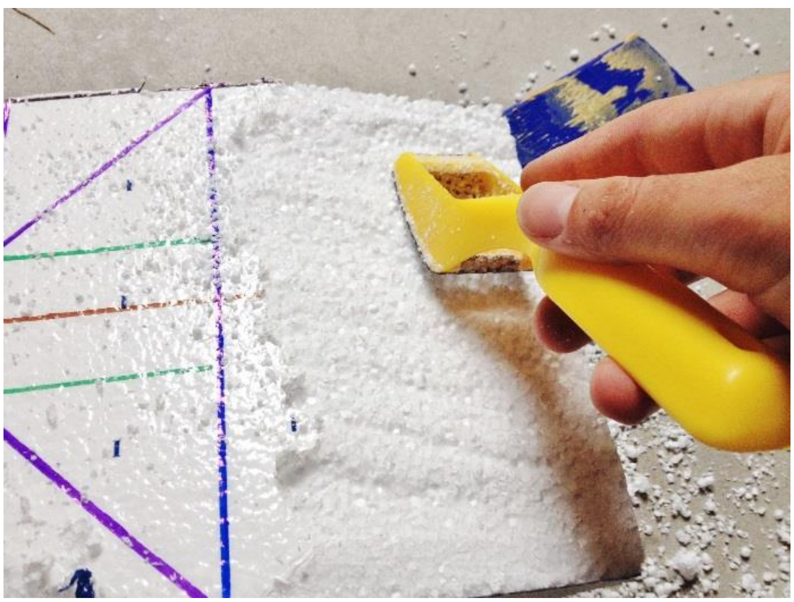
☐ Draw **straight lines** connecting the beginnings of your **kicktail** and **kicknose** lines to the ends of your **side concave lines**.



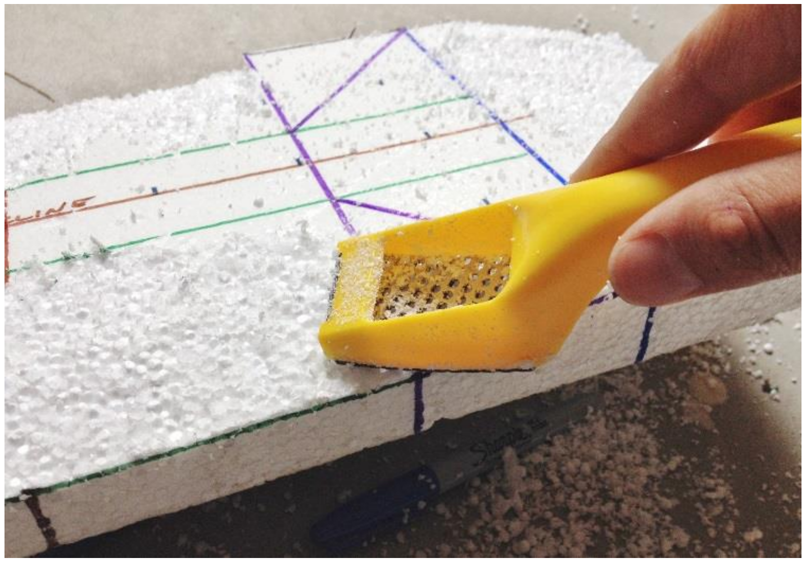
You're foam is now fully marked and ready for cutting!

☐ Use a saw to cut the foam away from your **kicktail** and **kicknose**. Make sure to stay slightly above your lines to give yourself some room for error.

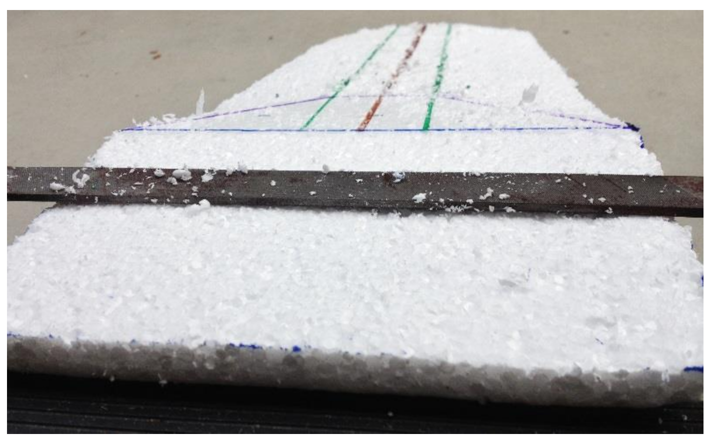
☐ Use a rasp-style shaver to flatten your **kicktail** and **kicknose**.



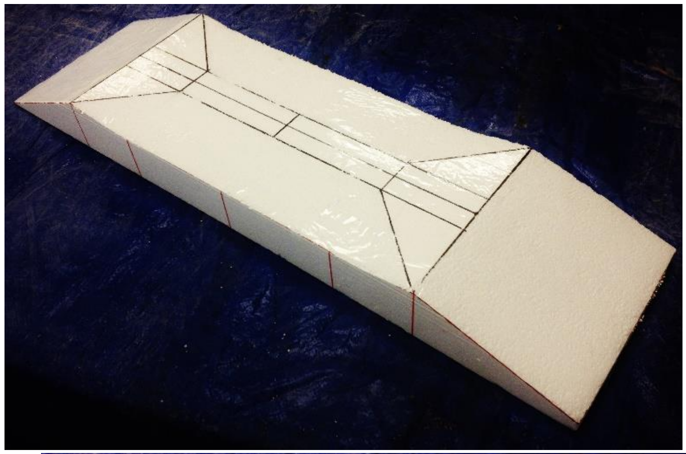
☐ Use a rasp-style shaver to shape the concave:

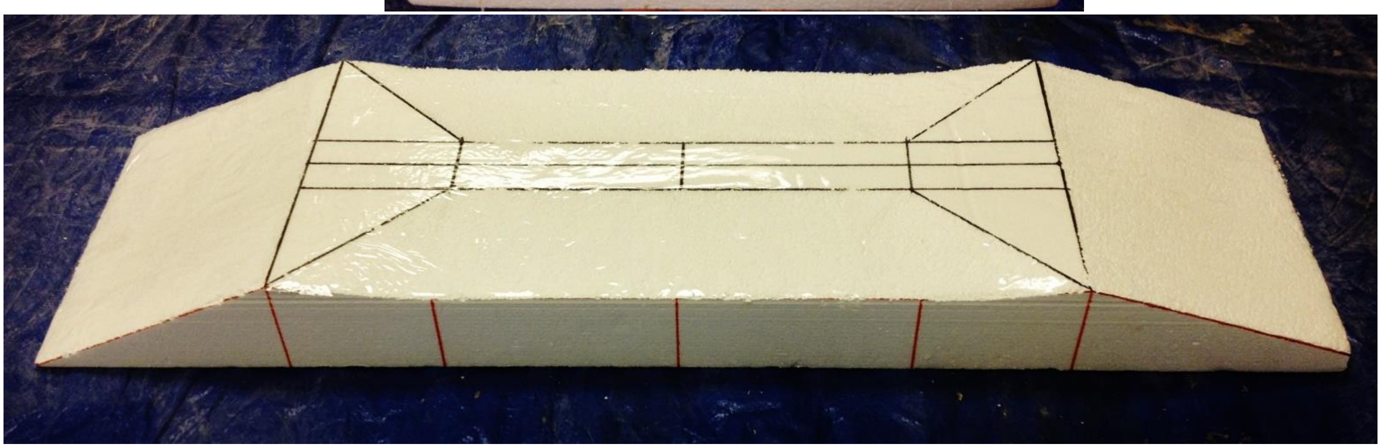


☐ Use a <u>straight edge</u> to check for flatness along your shaped surfaces:



☐ Cover the **top** of your mold with clear packing tape. This prevents your skateboard from getting glued to your mold.





Great job – you're done! Now go make some skateboards!

Lesson 4: Side Concave – Teacher's Guide

Applying math to determine mold geometry

The side concave lines on the foam mold can be manually calculated or calculated using the **concave calculator**.

1) The concave calculator:

The concave calculator can be accessed via: http://bit.ly/MoldConcave

Variables:

Width of skateboard: the width the student specified as part of his/her design.

Desired drop in concave: the concave dimension the student specified as part of his/her design.

Width of mold: the measured width of the foam block (this is usually 9.5 inches).

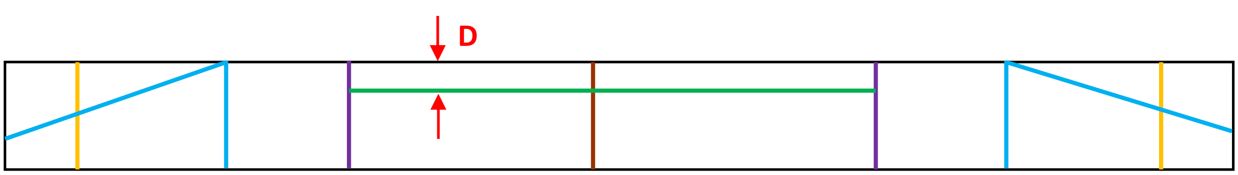
2) The quadratic equation:

How wide (w) will your skateboard be? w = _________ inches

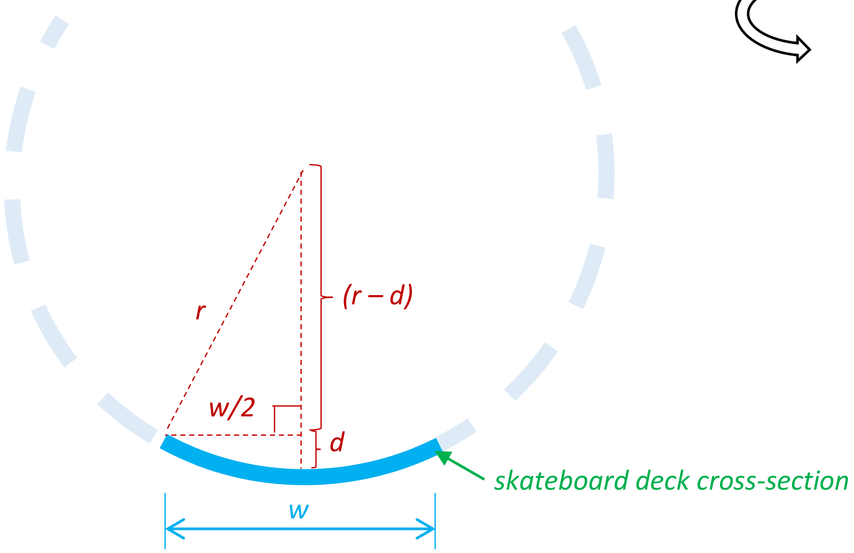
How much concave (d) do you want? (This is the vertical distance from the edge of the board to the center of the board.) d = _________ inches

How wide (f) is the foam mold? f = _________ inches

We need to solve for the dimension, D:



<u>STEP 1</u>: Find the radius (*r*) of your concave (*d*):

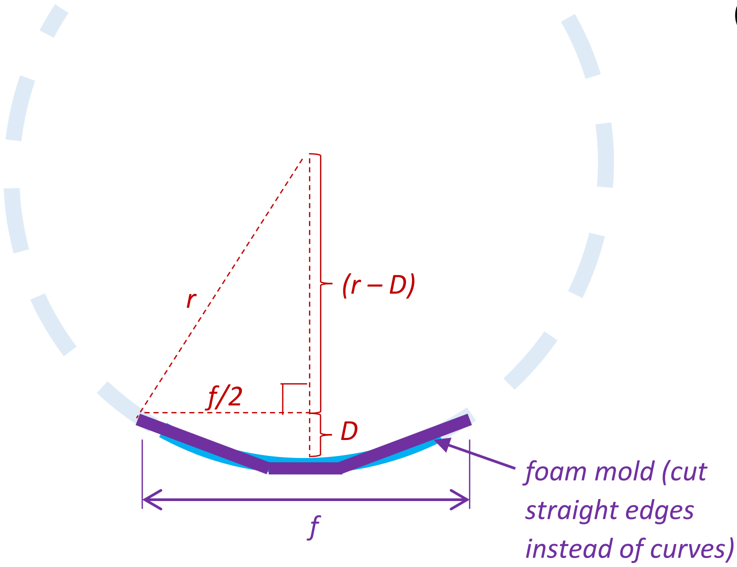


$$a^2 + b^2 = c^2$$

$$\left(\frac{w}{2}\right)^2 + (r - d)^2 = r^2$$

Solve for *r*

STEP 2: Now go backwards to solve for *D*, the distance from the top of your foam mold to mark for cutting:



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

$$\left(\frac{f}{2}\right)^2 + (r - D)^2 = r^2$$

Solve for D

Use the quadratic equation:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

when given

$$ax^2 + bx + c = 0$$

$$\frac{1}{4}f^2 + r^2 - 2rD + D^2 = r^2$$

$$D^2 - 2rD + \frac{1}{4}f^2 = 0$$

Lesson 5: Glue-Up Supplies Checklist

Checklist for preparing to glue your skateboard

- ☐ Vacuum bag with sealing tape installed
- ☐ Breather netting
- ☐ Veneers (2 face, 3 core, 2 cross grain)
- ☐ Glue
- ☐ Pump
- ☐ Vacuum (if using)
- ☐ Foam mold
- ☐ Glue roller
- ☐ Paper towels
- ☐ Ziploc bag for glue roller when done

Lesson 5: How Much Force?

Determining the force applied by the vacuum bag

The **Thin Air Press** was developed by **Roarockit Skateboard Company** as an alternative method to hydraulic pressing (Patents 7,132,030 and 2,390,264). It uses **vacuum** pressure to force the wood veneers against a mold.

Assuming we are able to apply a perfect vacuum (0 psia) inside the bag, how many pounds of force is created by the thin air press?

Current pressure (use http://www.wunderground.com): ____________ in Hg

Surface area of veneer: ____________ in^2

Pounds of force from Thin Air Press: ____________ lb

Hint: 1 in Hg = 0.491154 psi

in Hg: inches of mercury
psi: pounds per square inch

Lesson 6: Finishing Guide

A guide for finishing your skateboard deck

1. Remove your skateboard and mold from the Thin Air Press – **do not move your skateboard on the mold!**

2. Use a pencil and ruler to mark 3 points along the middle of your glued veneers. Connect the dots with a straight edge to make a line

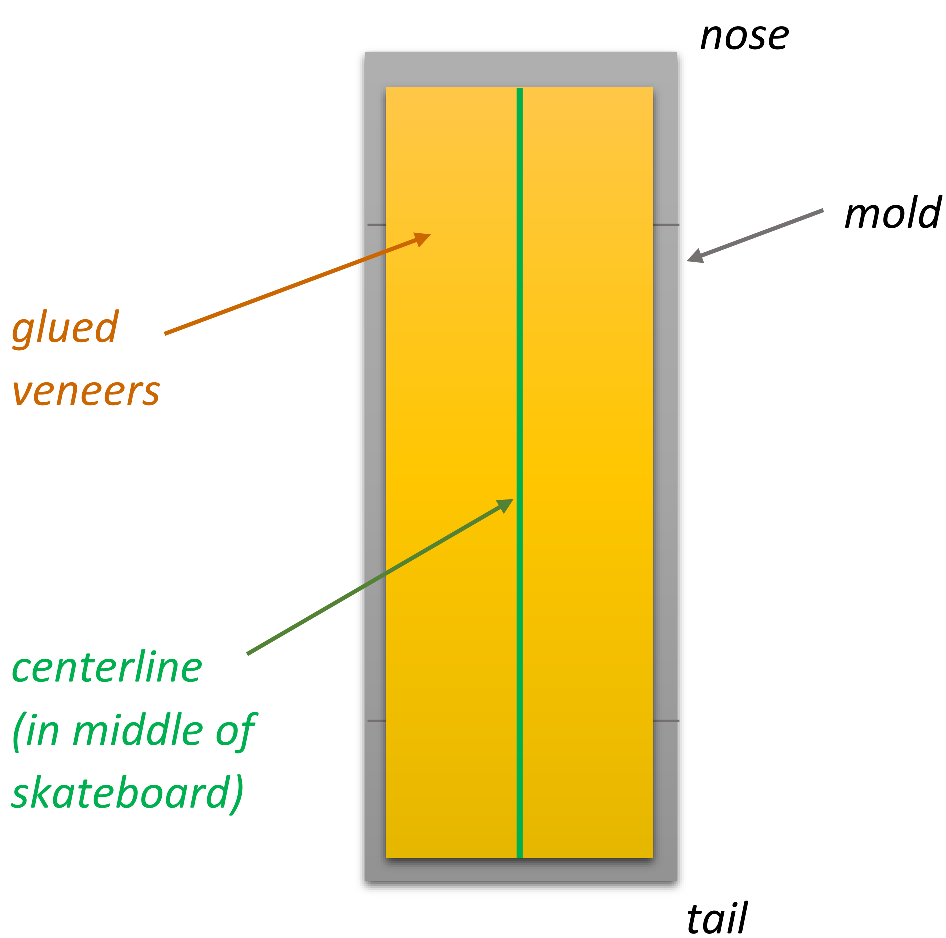


Figure 1

3. Also, before moving your board off the mold, mark the **kicknose and kicktail lines from your mold onto your board** (see Figure 2, below).

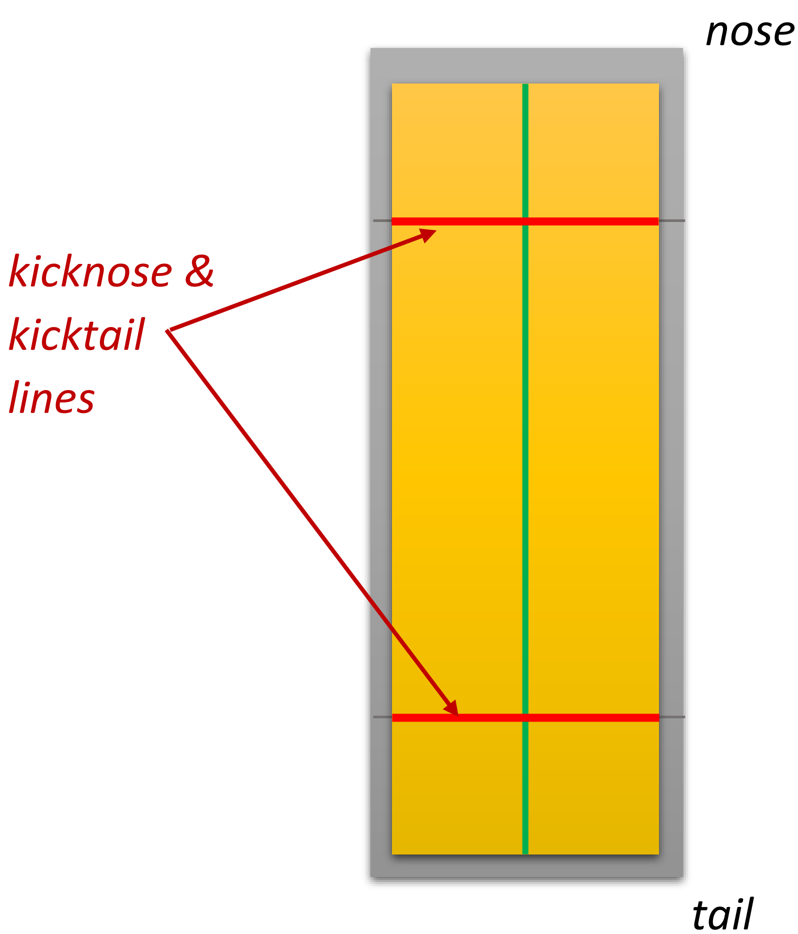


Figure 2

4. Make a paper template by printing your CAD drawing of the outline of your skateboard (the top view of your board) at **full scale**. This will take several sheets of paper – tape the sheets together where the pages split.

VIDEO PASSWORD: DesignBuildSk8

Watch the video tutorial at https://vimeo.com/194282901

If you have not yet made a CAD model of your skateboard, follow the video tutorials at: https://vimeo.com/album/4264653

If you are making a **"street"/popsicle style deck**: **https://vimeo.com/192306225**

If you are making a **cruiser style deck**: **https://vimeo.com/192306049**

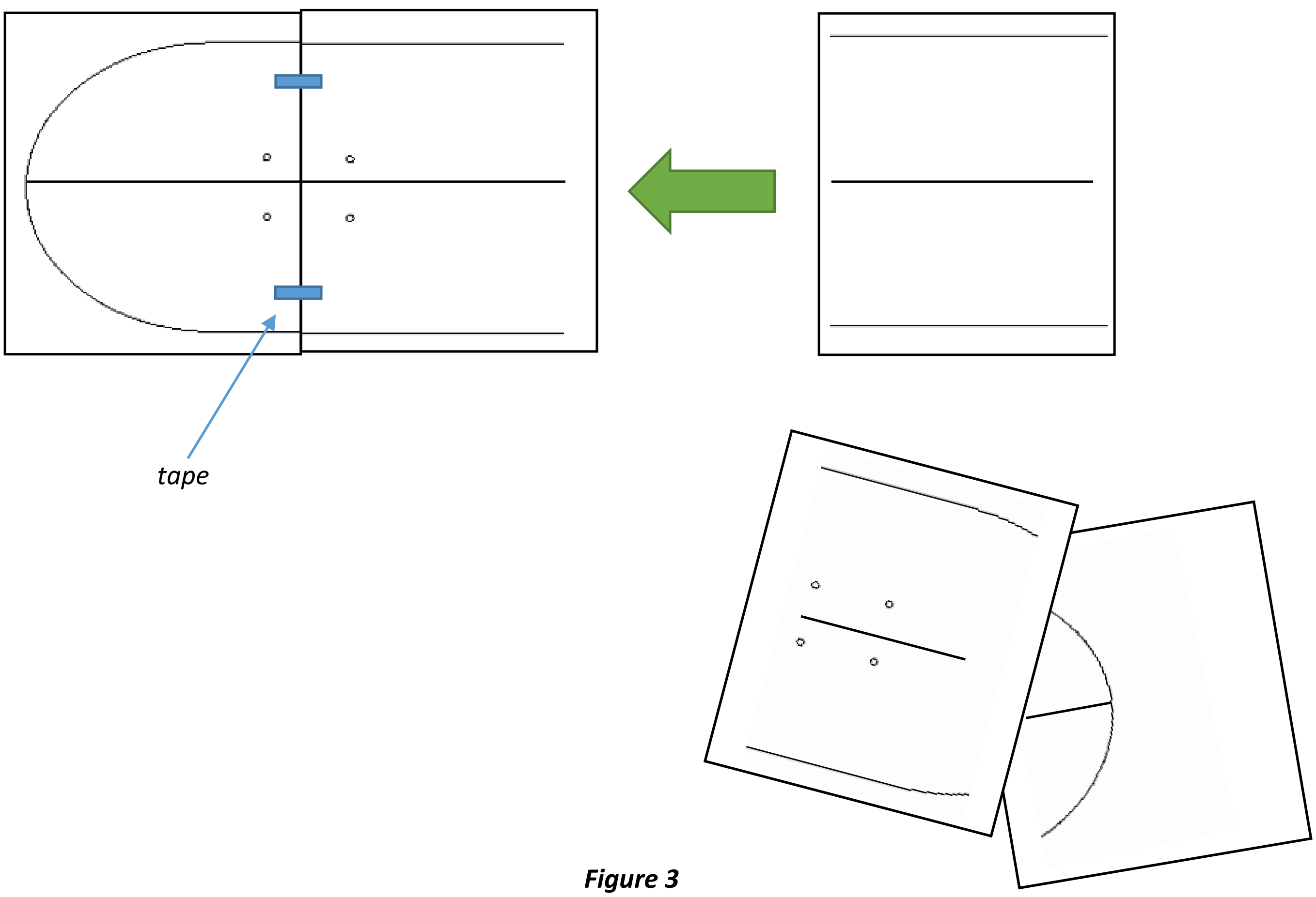


Figure 3

5. Cut out the outline of your paper template and mark the centerline and kick lines. Lay this over your board, lining up the centerline and kick lines.

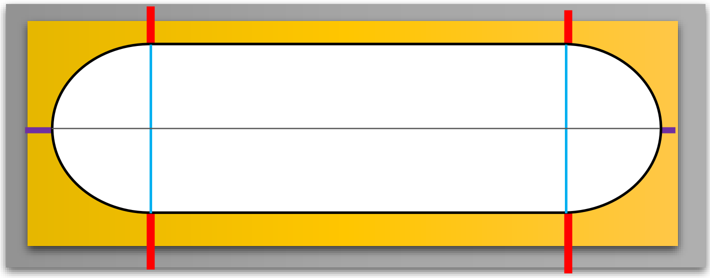


Figure 4

You may want to cut small diamonds along the centerline of the template, to allow you to better line-up the template:

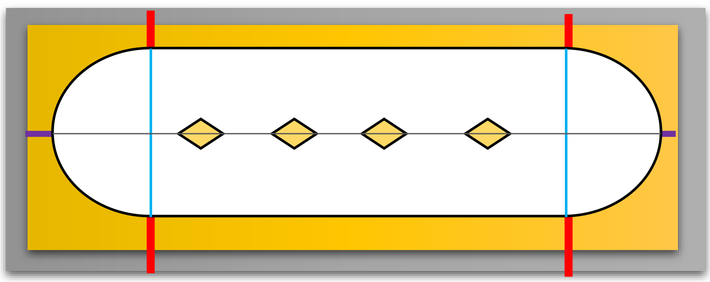


Figure 5

6. Trace the outline onto your uncut board with a pencil.

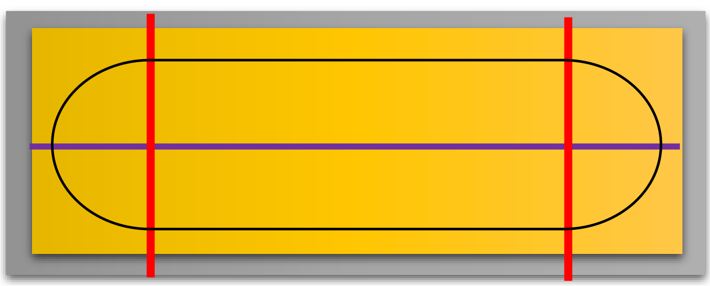


Figure 6

7. Using the truck hole template, mark the locations for your truck holes by lining up the points of the template's diamonds with the centerline you drew. The truck hole template is marked to indicate which holes to use for specific wheelbases – for example, if you want a 14" wheelbase, make a mark in each hole labeled as 14".

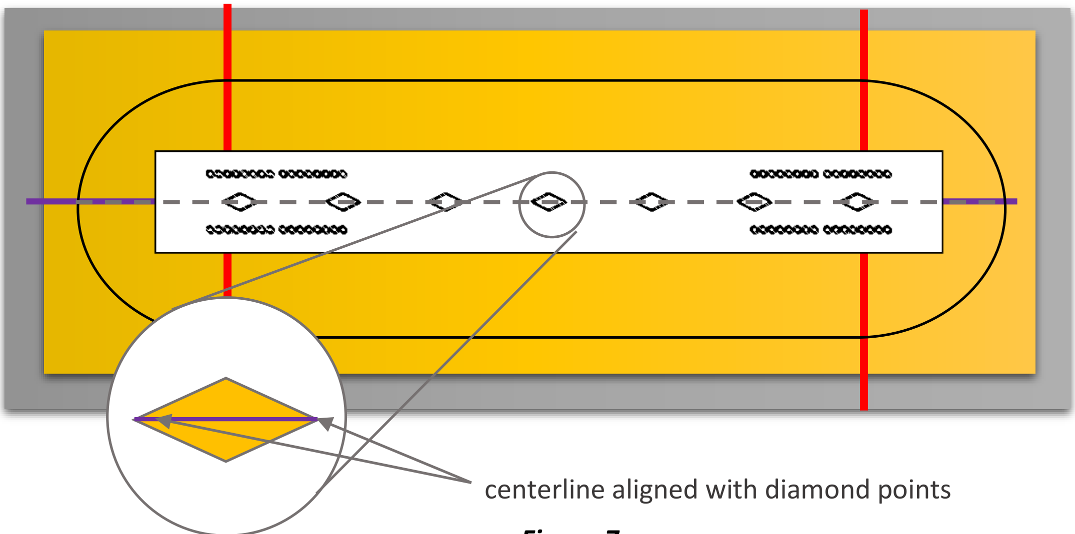


Figure 7

If you do not have this template, you can use your template OR use the centerline on your molded board for individually marking truck holes by hand. Truck hole dimensions (from the center points of the holes) are 2.125" (across the board's length) by 1.625" (across the board's width):

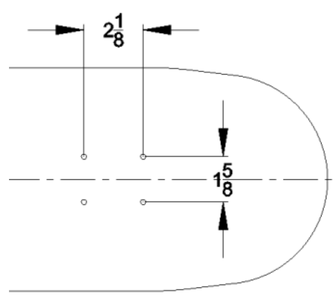


Figure 8

8. Now that your board outline has been made and your truck holes have been marked, follow your instructor's directions for cutting your skateboard and drilling your holes*.

CAUTION: IMPROPER USE OF POWER TOOLS MAY RESULT IN INJURY OR WORSE. FOLLOW ALL SAFETY PRECAUTIONS FOR EACH POWER TOOL USED.

Here is a checklist to complement (and not replace) your instructor's safety guidelines:

Safety checklist:

- **Safety glasses**
- **Dust mask**
- **Loose hair tied back**
- **Loose clothing/accessories rolled up or removed**
- **Closed toe shoes**
- **Ear plugs (recommended)**

*Drilling note:

a. Use a hammer and nail to mark the EXACT centers of the bolt holes. These need to be perfect in order to mount your trucks.

b. Drill a **pilot** hole where you marked each of your hole points. Use a 1/8" diameter drill bit. The pilot hole creates a small hole and helps cut a smoother hole with less chipping.

c. Drill a hole with the 3/16" **or** 13/64" diameter drill bit.*

***Drill straight**! If your holes are angled, they might not line up with your trucks' holes. It's a good idea to use a truck and bolts to mount on your skateboard immediately after drilling the holes to confirm proper alignment. 3/16" bits will make a tight fit for the bolts.

9. Sand your skateboard using the coarsest grit sand paper (lowest number) first, then sand using the highest grit sand paper (highest number).

Low grit	=	coarse	=	more material removal	=	rougher surface
High grit	=	fine	=	less material removal	=	smoother surface

10. Use a foam brush to brush the sealer on your board, following the instructions on the can.*

*Test your art medium and sealer beforehand to determine whether to apply art before or after sealing. (Testing can be done on scrap wood.) For example, if using Sharpie markers for art, it's best to seal the board at least once first to prevent the Sharpie from bleeding in the wood. On the other hand, some paints don't apply well on top of sealer, so paint may need to be applied before any sealing is done. Also, make sure to wait for paints and sealers to fully dry between coatings.

SKATE SAFE AND HAVE FUN!

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ADDITIONAL RESOURCES:

Visit www.OpenSourceBoards.com

About Open Source Skateboards

Hi!

My name is Beau, and Open Source Skateboards (OSS) is a project I started in 2014. The mission of the project is to empower and excite others (especially youth) to be creative.

I currently work full-time as a mechanical engineer in Oceanside, California while running OSS on the side. I've personally taught this program in various schools and makerspaces, and regularly use the content provided in this curriculum.

I have also been a skateboarder since I was 10 years old, and still skate. I am competitively active in freestyle skateboarding and teach skateboarding via the OSS YouTube channel.

I hope you find this curriculum as useful as I have. Please feel free to contact me with any questions or feedback (www.opensourceboards.com/contact).

- Beau Trifiro