When Will We Ever Use This?

Benchmaking 101

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Purpose

- Our purpose today is to act as students who have been asked to build a 1:4 scale model of a real park bench.
- Through the process, we will be exercising several math and geometry skills as well as critical thinking skills.
- This can be done in groups in your classroom. It does require a bit of preparation and a reasonable expense, but a kit can last for years.
- If you are making one kit, making two kits takes only a little bit longer. So, make four or five at once.

Equipment

- The kit
  - 12 ft of 1x2 pine board (I use 3 six-foot sticks)
  - Paint if desired (easier removal of glue)
  - Miter saw with adjustable angles
  - Chunk of 2x4 pine board
- Activity Day
  - Wood Kit
  - Calculator
  - Hot glue gun
  - Protractors (paper/plastic/both)
  - Rulers
  - Scraper and hair dryer to remove glue

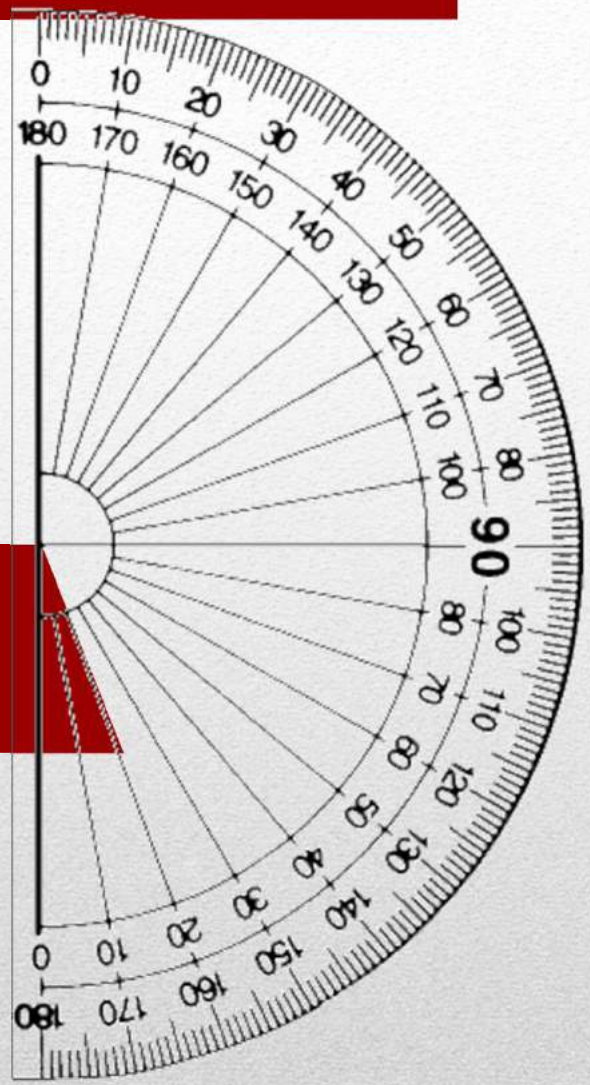
Skills Exercised

- Following basic, specific directions
- Critical thinking
- Scaling measurements up and down
- Reading a fractional scale
- Fractions and decimal equivalents
- Transferring measurements
- Calculating and using supplementary angles
- Calculating and using complementary angles
- Identifying various geometric shapes
- Projecting lines to form hypothetical shapes
- Using properties of triangles
- Transitioning from 2D to 3D representation (nets)

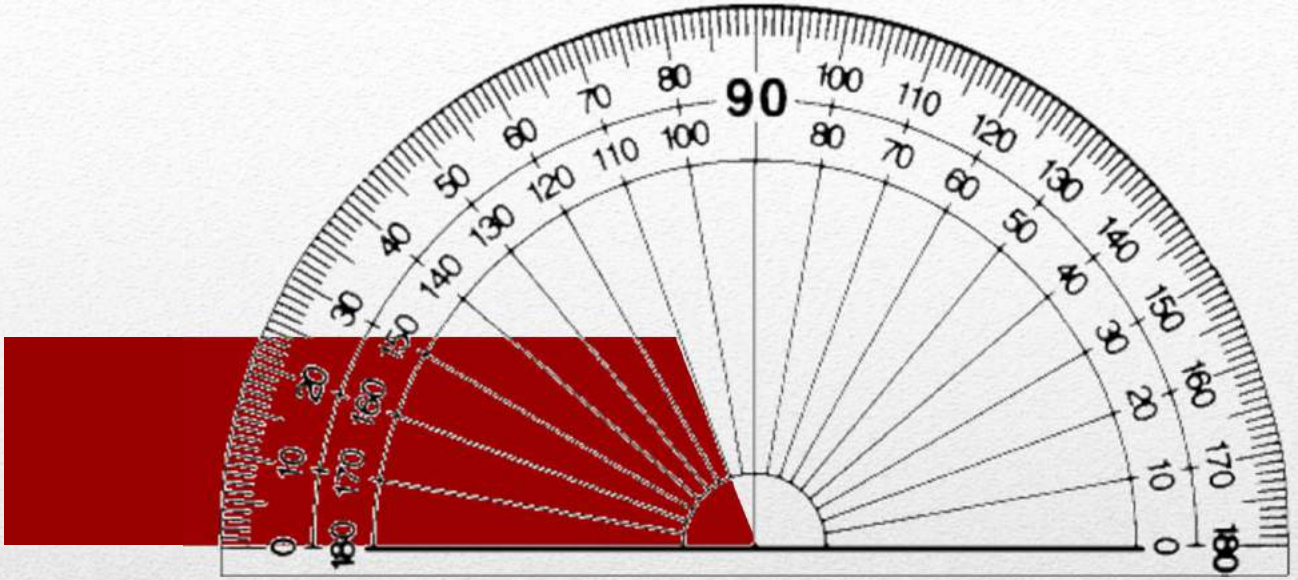
Caveats

- Measurements on the actual wood pieces are to the nearest eighth of an inch
- Please be conservative with the amount of glue used; it doesn't take much.
- This bench that we are building is not a true scaled replica of the actual bench. This is because the wood is accurately scaled on length but not on width and thickness.
- Carpenters measure angles differently than we do in the classroom, so I have converted everything to classroom techniques for the exercise.

How we will measure angles this morning

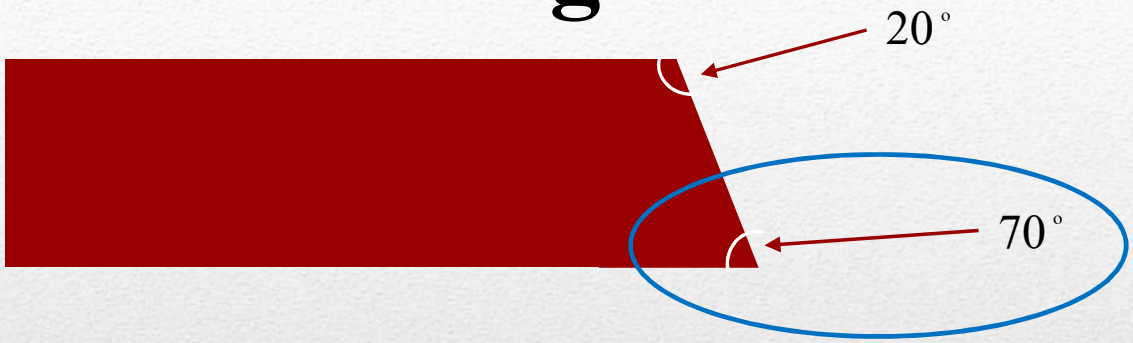


- A carpenter would call this a 20° angle; measured on the short axis of the board



- A student would call this a 70° angle; measured on the long axis of the board.

How we measure angles this morning



- A carpenter would call this a 20° angle
- A student would call this a 70° angle
- I will be using the student version for all angle discussions today; measured on the long axis.

Warm up Exercise

- Measure the diameter of the Oreo in inches.
- Scale it up using a 1:4 scale
- How big is the scaled up Oreo?

Critical Thinking

- As we scale models up and down, the length, width, and height of the structural members will change.
- Will the angles change? How is a 3-4-5 triangle like a 6-8-10 triangle?

When is a 2x4 not a 2x4?

When is a 2x4 not a 2x4?

- Measure the actual width and thickness of your piece of 2x4
- The 4” width is actually _____ ”
- The 2” thickness is actually _____ ”
- Using a 1:4 scale, the width of the model wood should be _____” but it is _____”.
- Using a 1:4 scale, the thickness of the model wood should be _____” but it is _____”.

Accountability and Grouping

- How many pieces of 1x2 pine do you have?
- Group all of your pieces into piles of identical pieces. How many piles do you have?
- Notice that one piece in each group is lettered with A through F.

Find

- Find the piece that would be 47” long on the real bench. How long is the scaled down piece? _____”
- What letter is it? _____
- Mark the length of the scaled down piece on this image

Why the finer graduations at lower measurements?

- Mark the piece of the scaled up piece on this image

Find

- Find the piece that looks like a parallelogram. What letter is it? _____
- Is it actually a parallelogram? Why or why not? What are the two angles? _____ and _____
- How long was this scaled down piece before the angles were nipped off of each end? _____"
- Mark the length of the scaled down piece on this image

- Mark the length of the scaled up piece on this image

Equate

- Mark 26 3/8 (1)
- Mark 26 4/8 (2)
- Mark 26 4/16 (3)
- Mark 26 15/16 (4)

Mark 27.0625 (5)

Mark 27.25 (6)

Mark 27.875 (7)

Mark 27.6875 (8)

Find

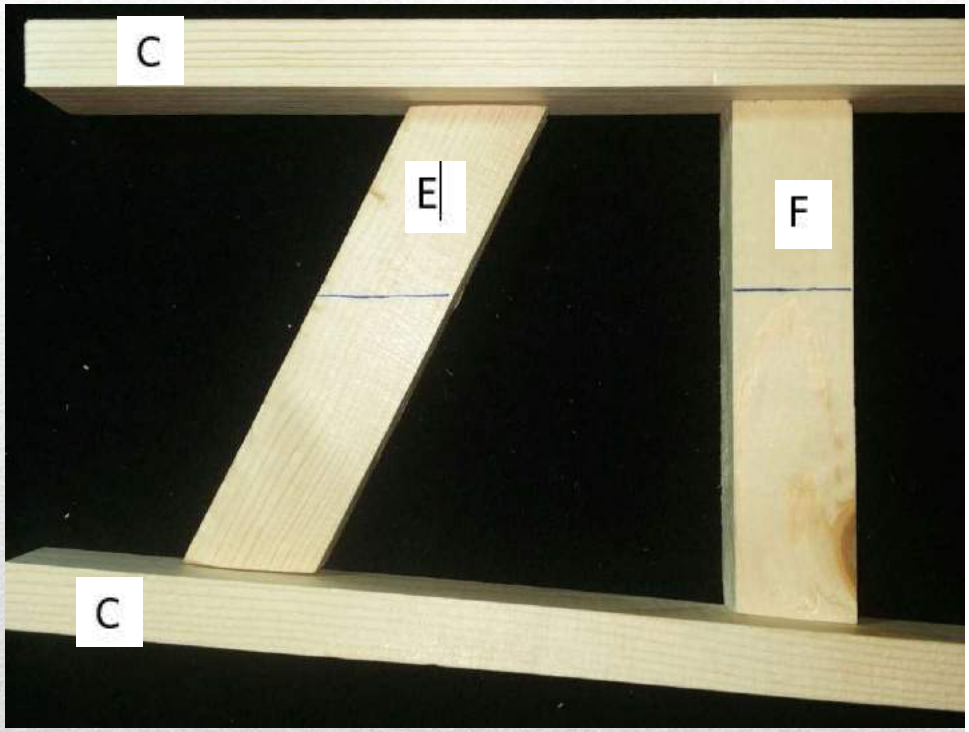
- Find the piece whose end angles are 90° and 62.5°. What letter is it? _____
- Find the piece whose supplementary angle is 95°. What letter is it? _____
- Find the piece whose complementary angle is 12.5°. What letter is it? _____

Find

- Find the piece whose end angles are 90° and 62.5°. What letter is it? _____D
- Find the piece whose supplementary angle is 95°. What letter is it? _____F
- Find the piece whose complementary angel is 12.5°. What letter is it? _____B

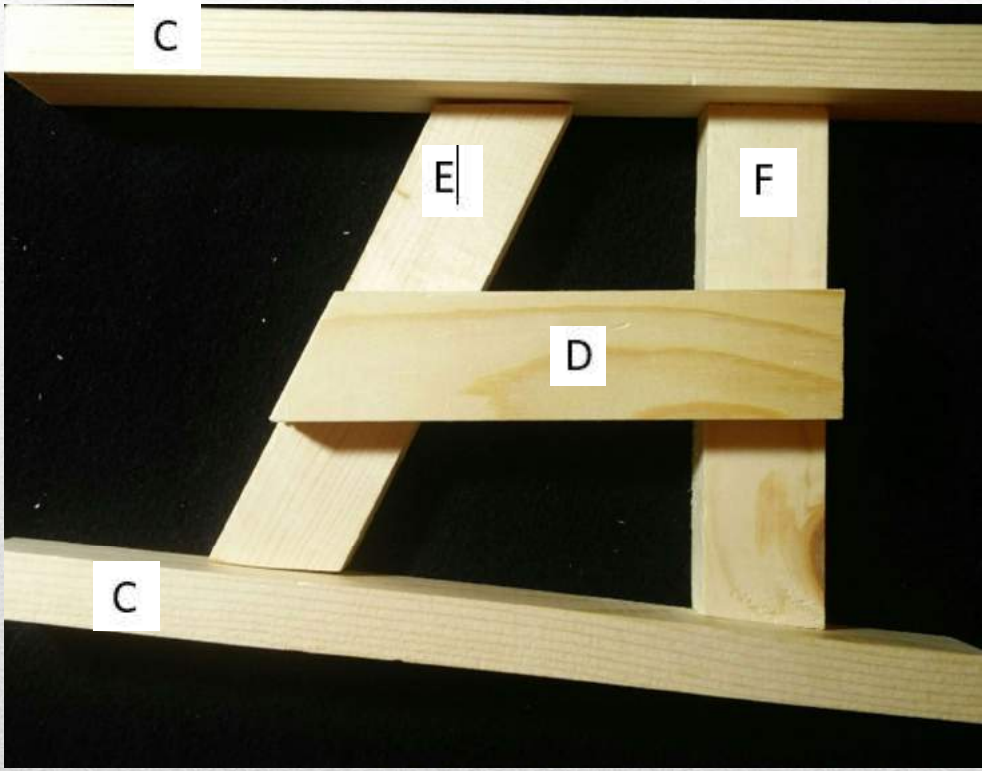
Let's begin construction: Left Side

- Use two C pieces top and bottom. The two C pieces are not parallel.
- Put the F piece on the right and the E piece on the left as shown.
- Notice the blue lines on E and F.



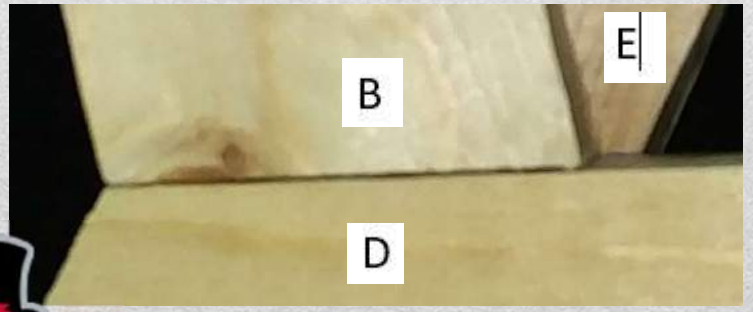
Left Side continued

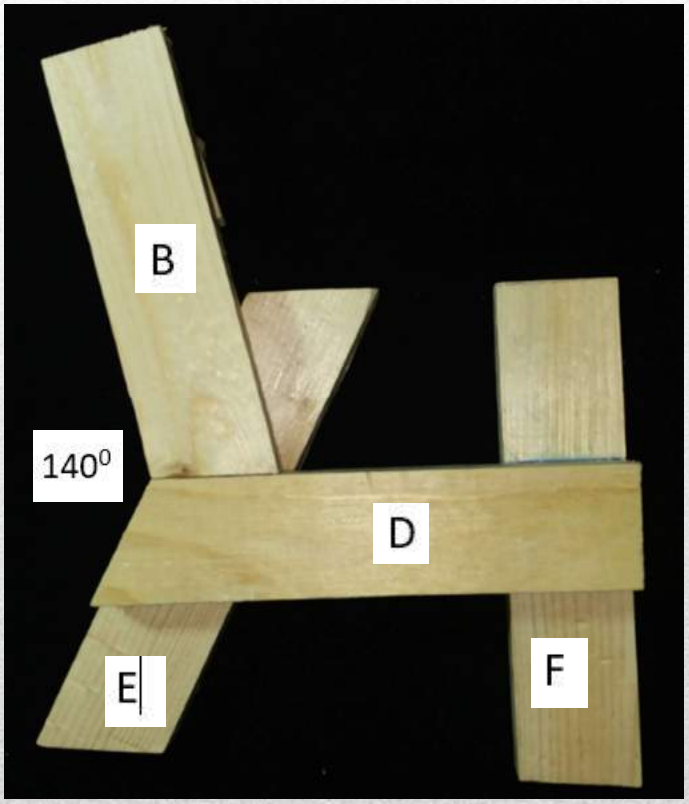
- Now, add a D piece as shown.
- Align the D piece with the two blue lines on E and F.
- Ensure that D is perpendicular with F.
- Ensure the ends of D are perfectly flush with the sides of E and F.
- Ensure that the top of D is parallel with and adjacent to both blue lines on E and F
- Glue D onto E and F



Add Left Back Support

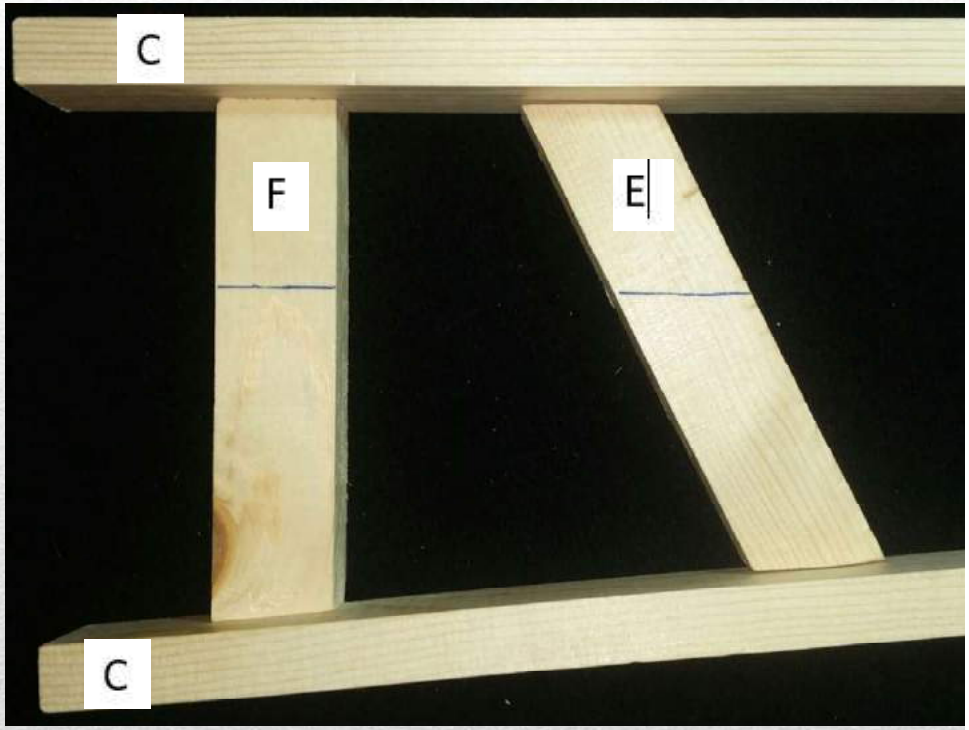
- Glue B on top of E with the angled end of B abutted against the top of D.
- Ensure that B and E are forming a 140° angle.
- Ensure that the angled end of B is properly aligned with the intersection of E and D.





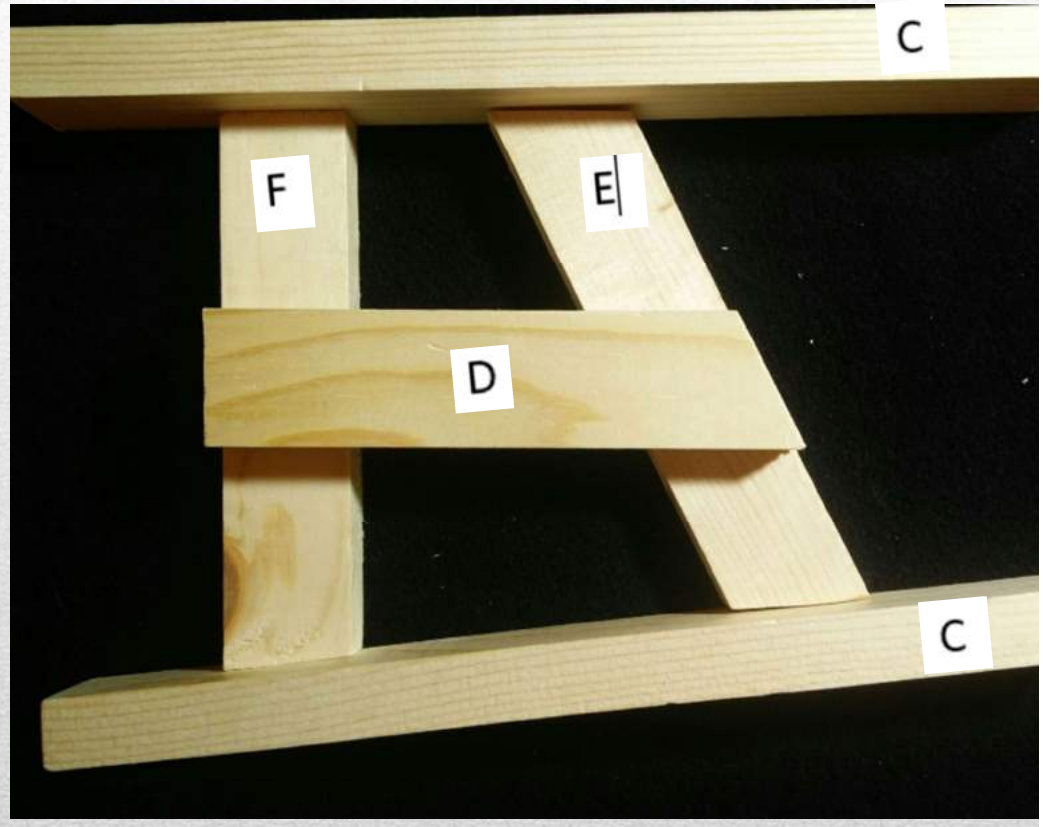
Right Side

- Use two C pieces top and bottom. The two C pieces are not parallel.
- Put the F piece on the left and the E piece on the right as shown.



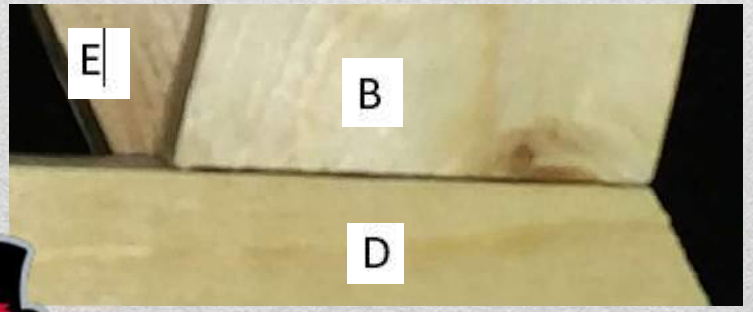
Right Side continued

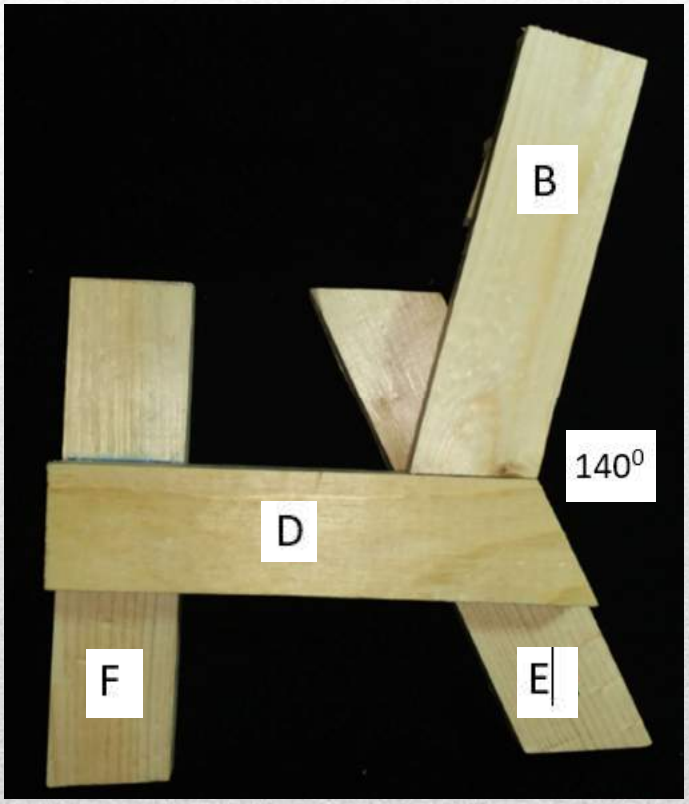
- Now, add a D piece as shown.
- Align the D piece with the two blue lines on E and F.
- Ensure that D is perpendicular with F.
- Ensure the ends of D are perfectly flush with the sides of E and F.
- Ensure that D is parallel with and adjacent to both blue lines on E and F
- Glue D onto E and F



Add Right Back Support

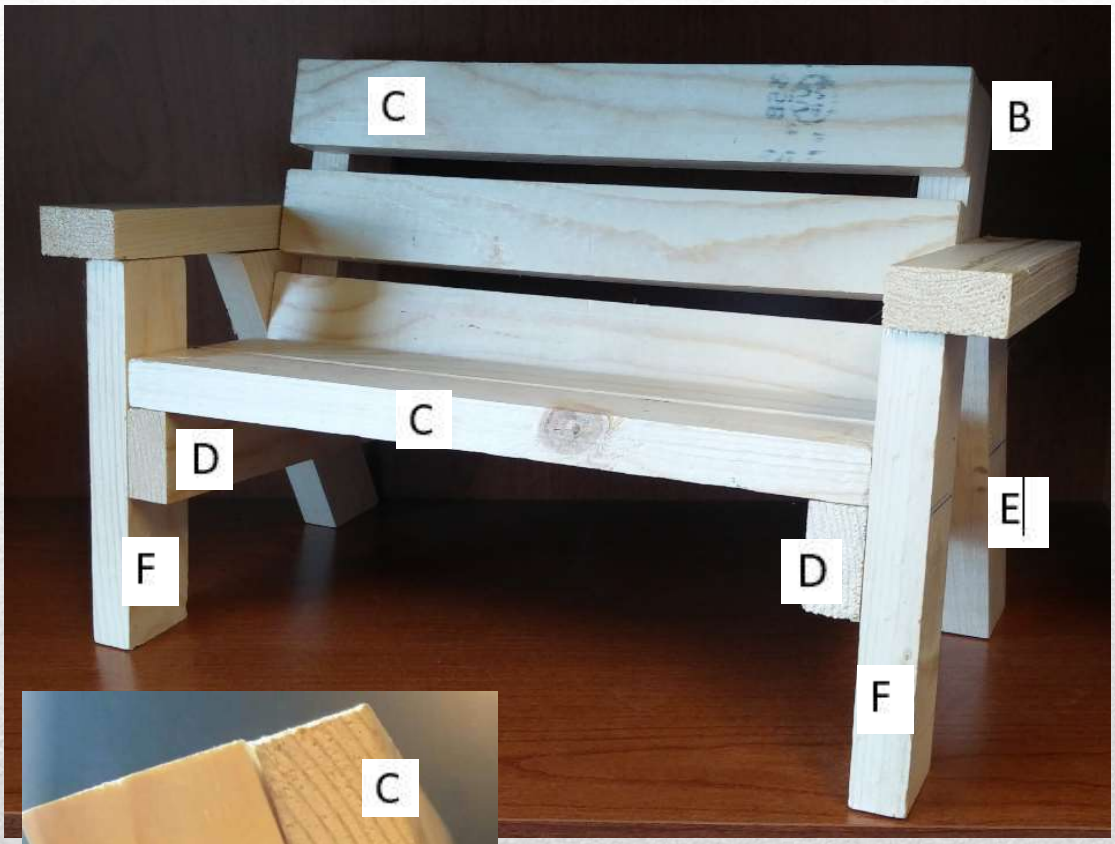
- Glue B on top of E with the angled end of B abutted against the top of D.
- Ensure that B and E are forming a 140° angle.
- Ensure that the angled end of B is properly aligned with the intersection of E and D.

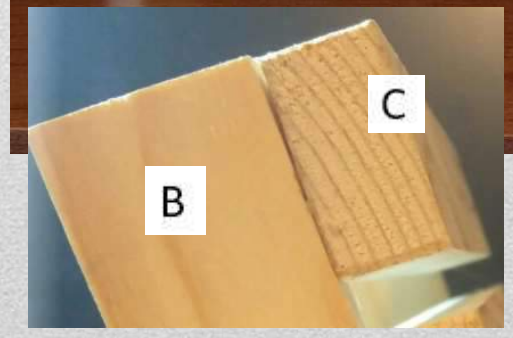




Add Slats for Back and Seat

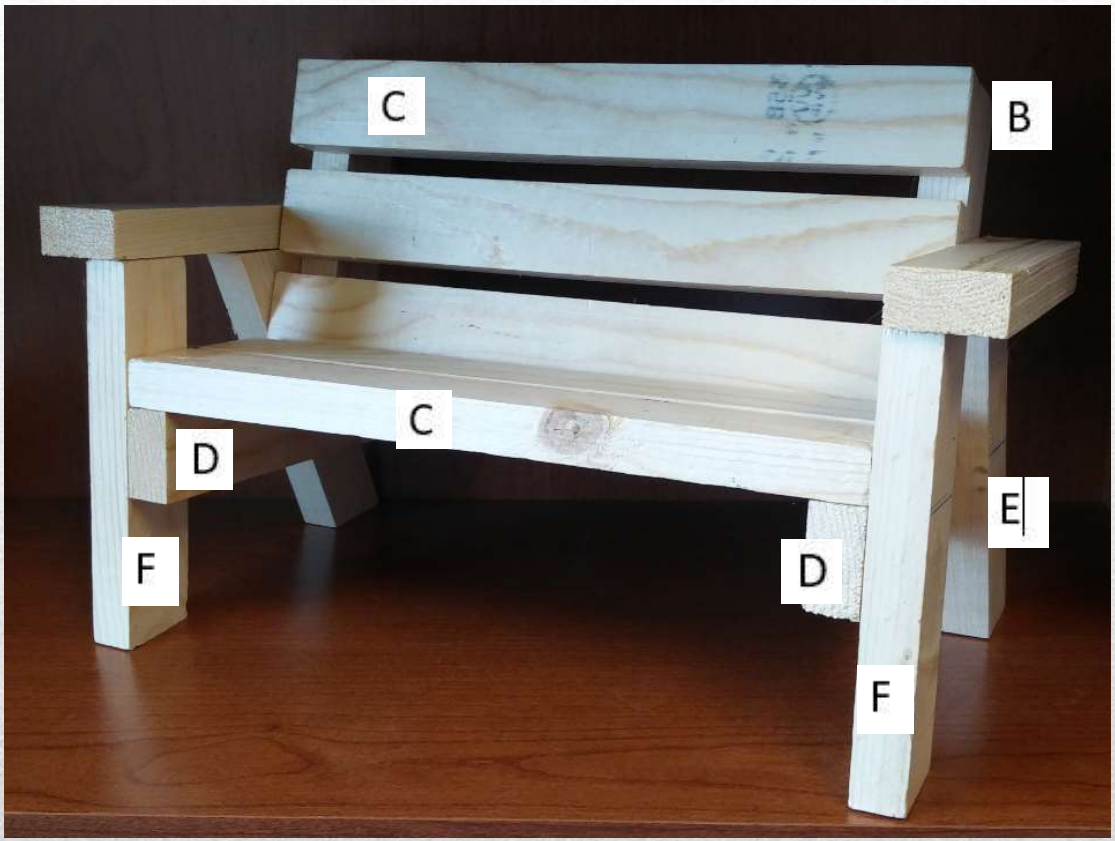
- Glue the frontmost C onto the seat.
- Glue the upper most C onto the back. Ensure the ends of C are flush with the sides and ends of B.





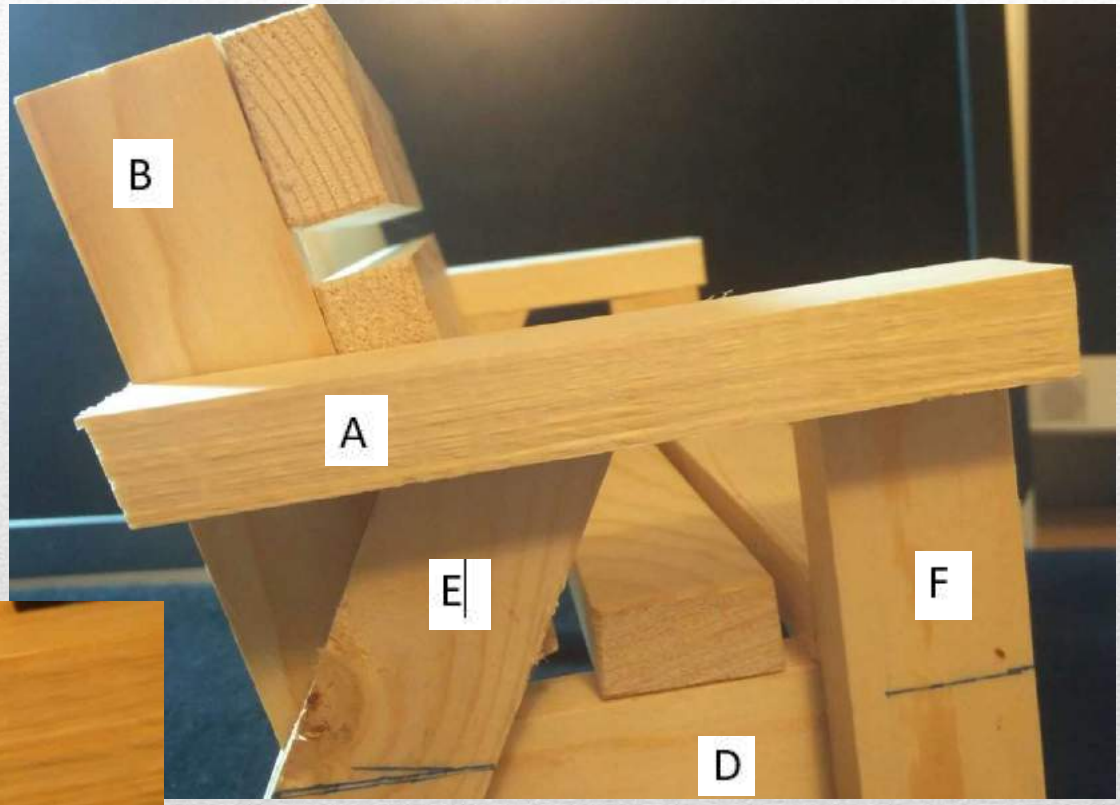
Add More Slats

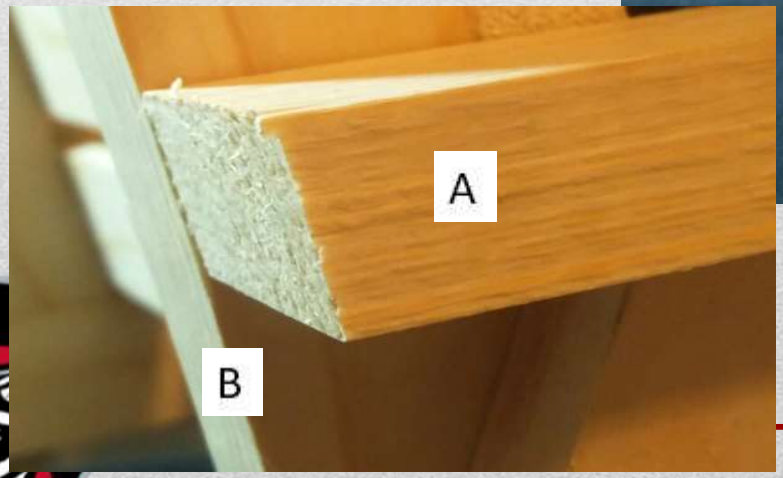
- Using the 1/4” spacer between the C pieces, add the next C to the back and the next C to the seat.
- Add the third C to the back of the bench.



Add the Arms (L and R)

- Glue A to the tops of E and F.
- Ensure that the back of A is flush with the back of B.

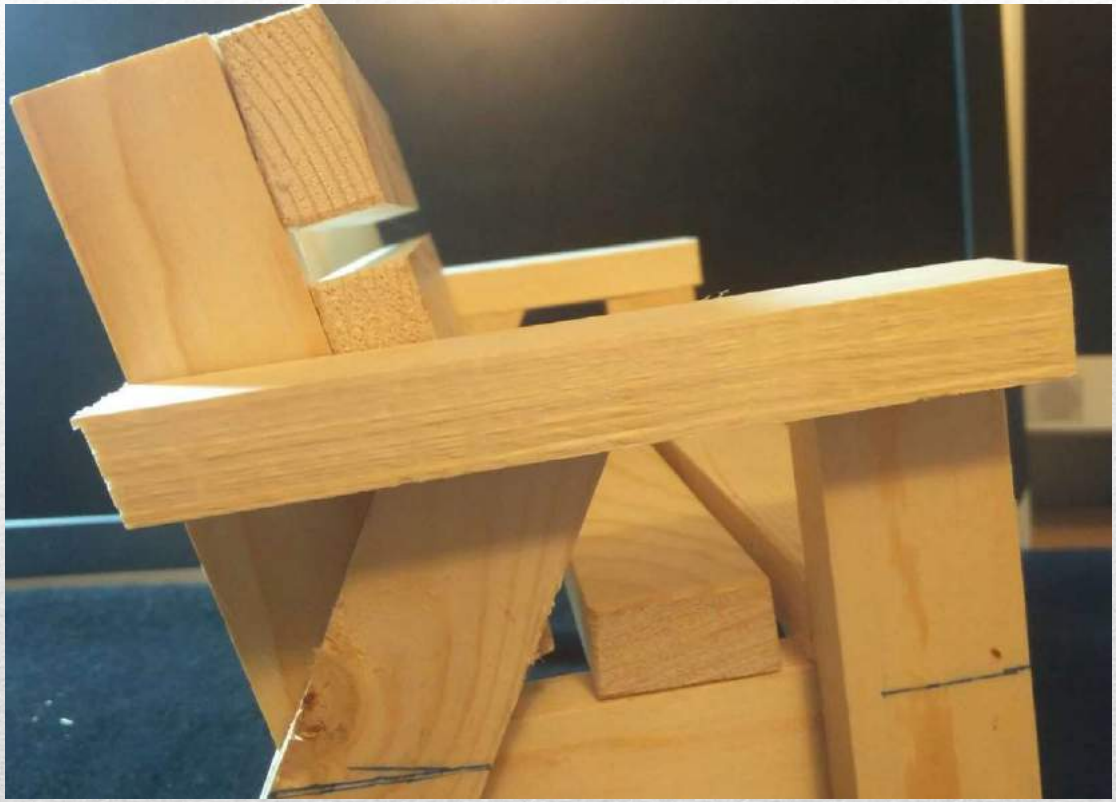




And now we have a bench!

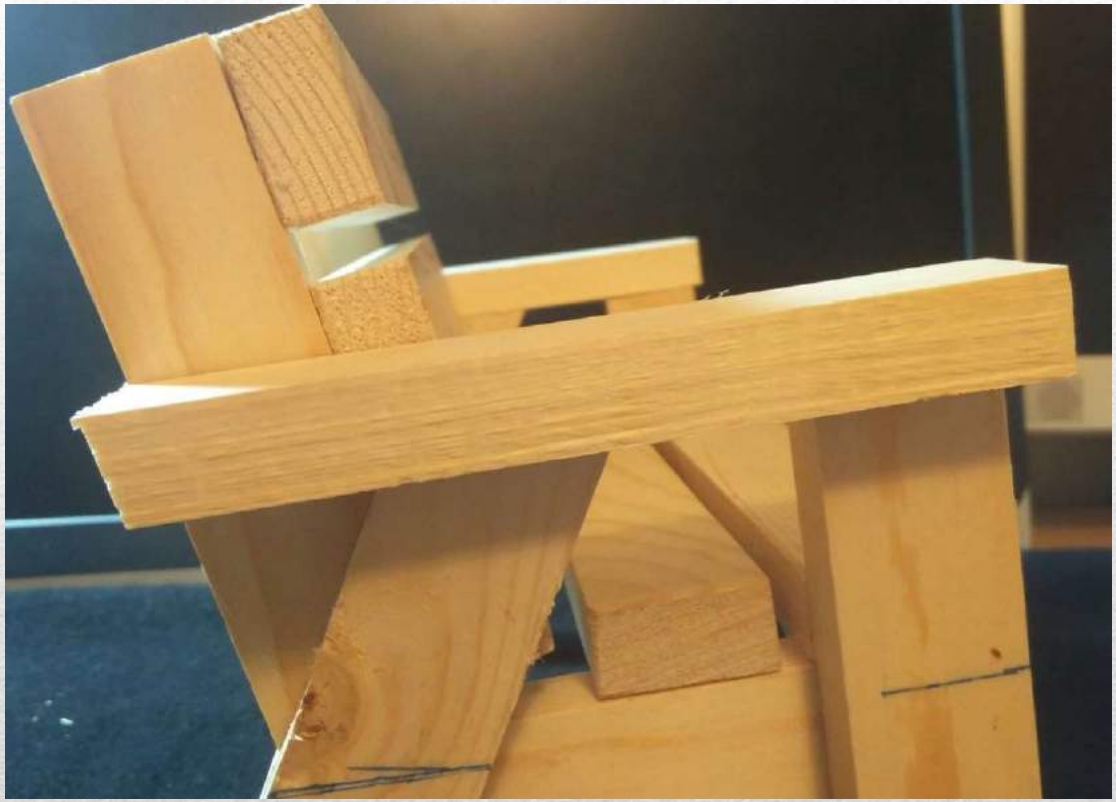
Parallel Members?

- Is the seat parallel to the ground? Long axis? Short axis?
- Are the arms parallel the seat?
- Are the arms perpendicular to the back?
- Is the seat perpendicular to the back?

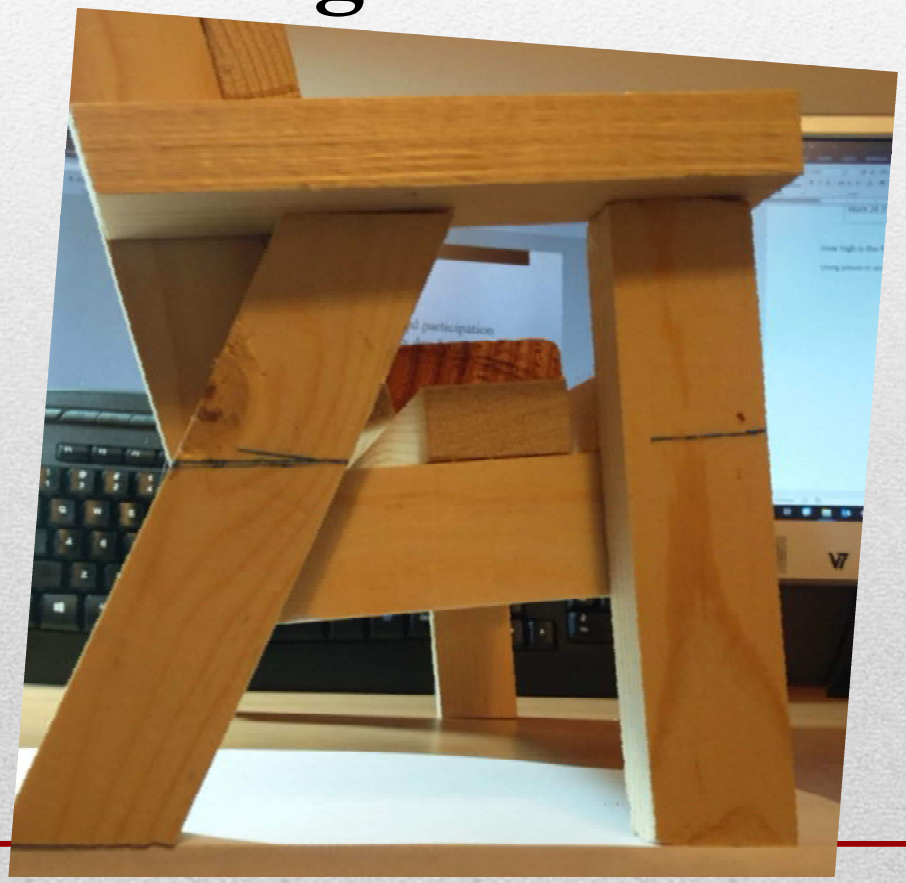


Height?

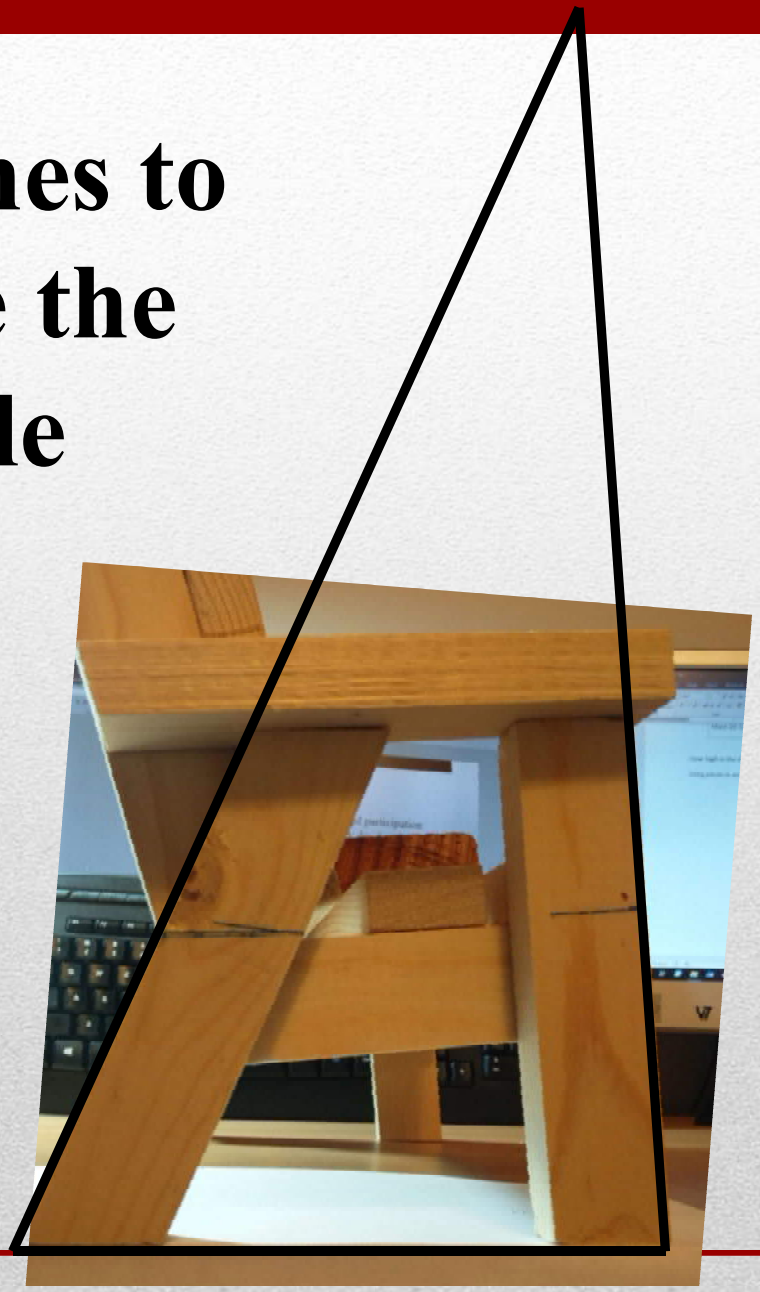
- How high is your model?
- How high is the real bench?



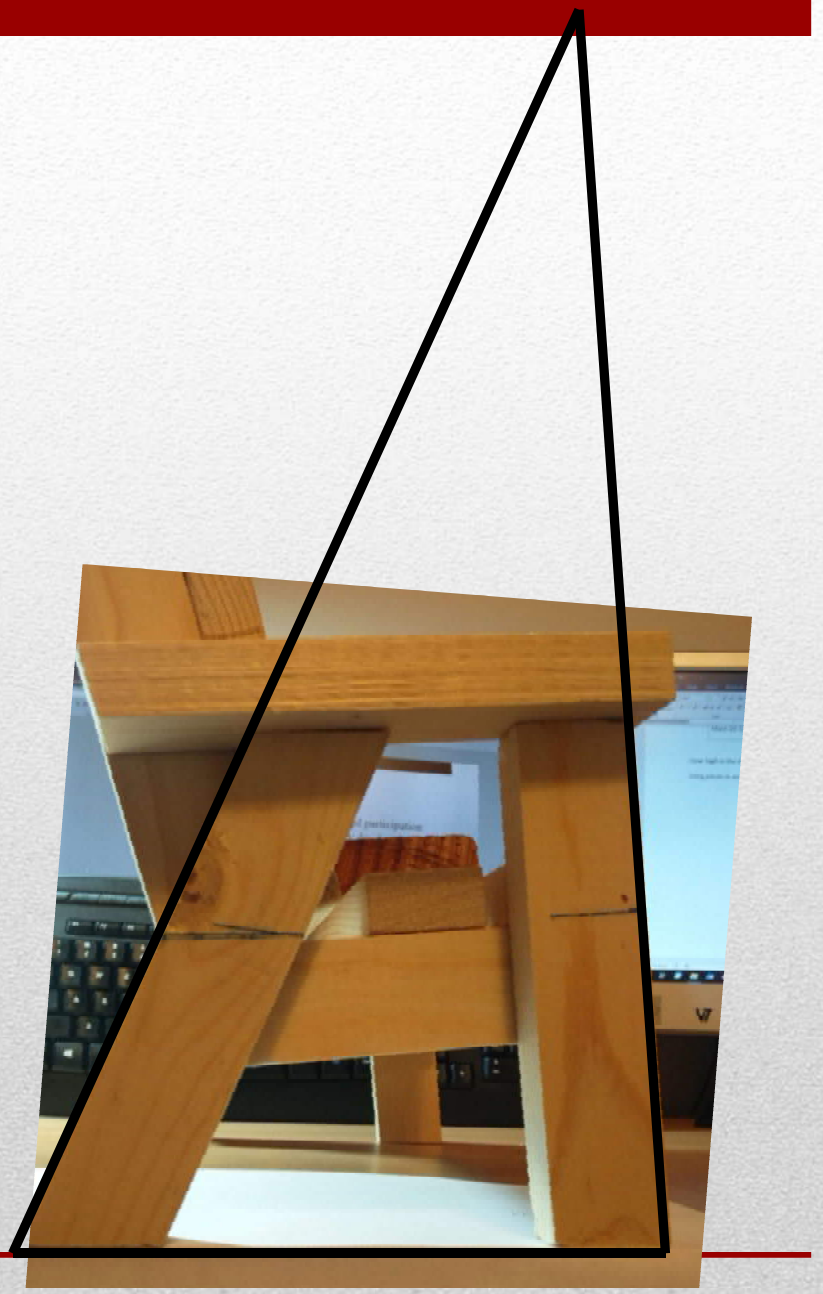
Consider the partial triangle formed by the legs with the ground



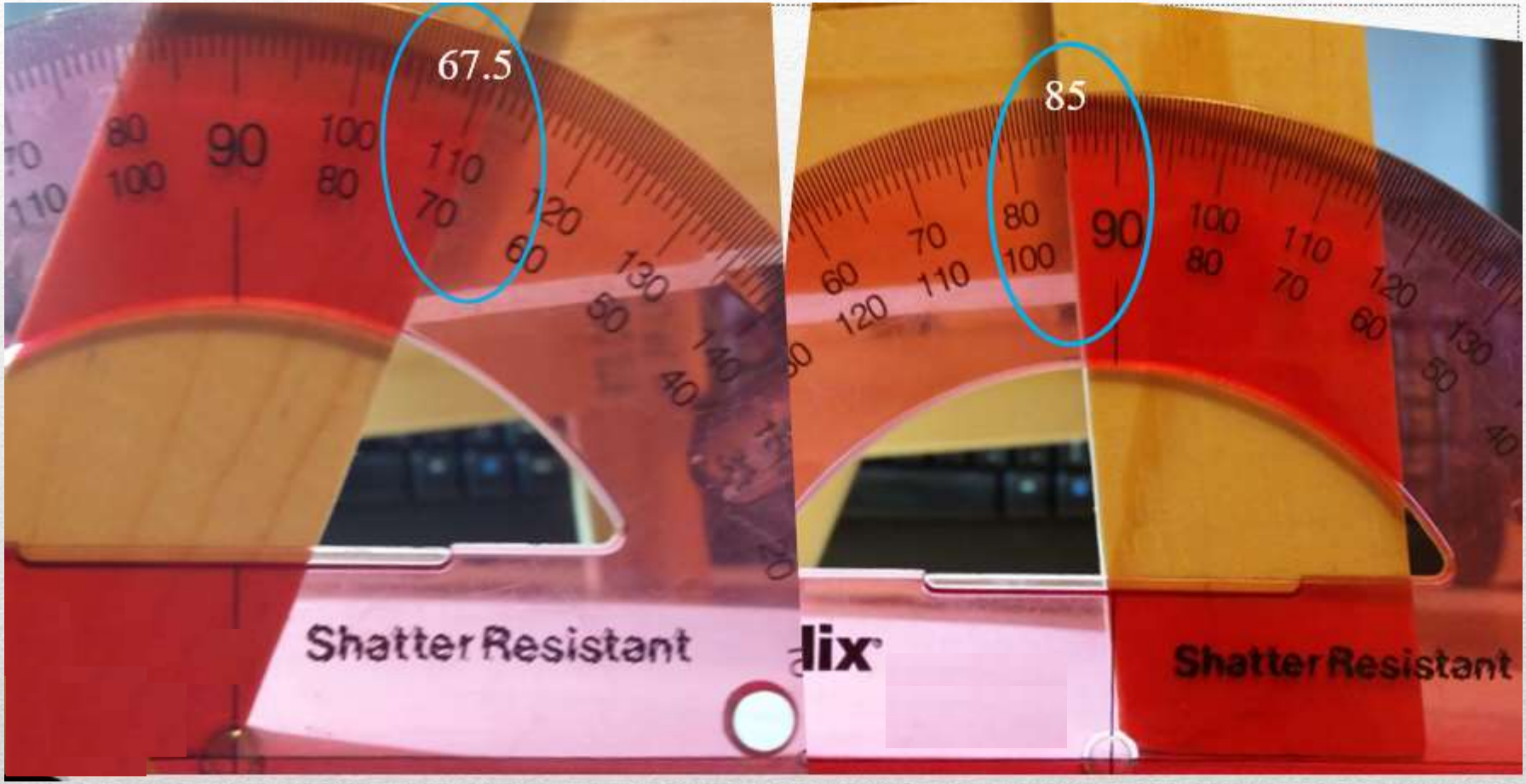
Project lines to complete the triangle

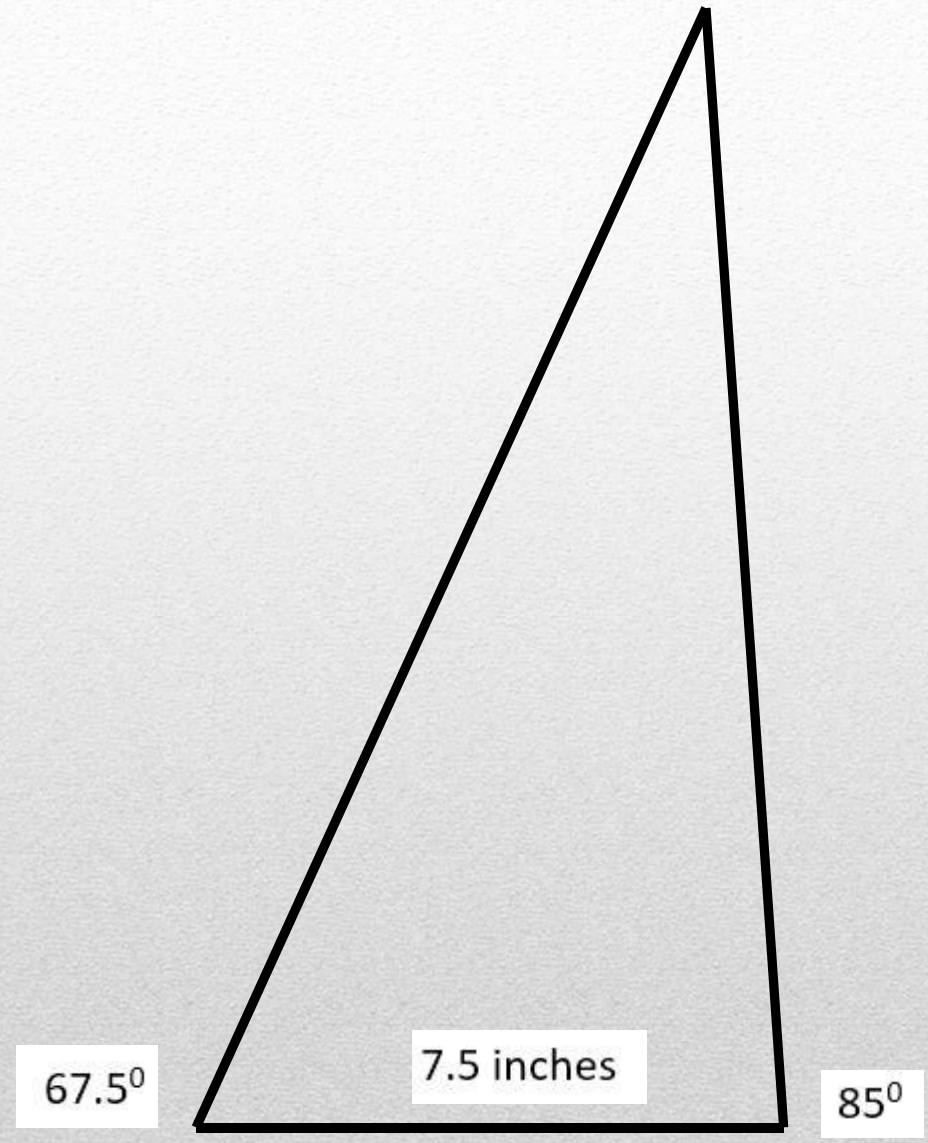


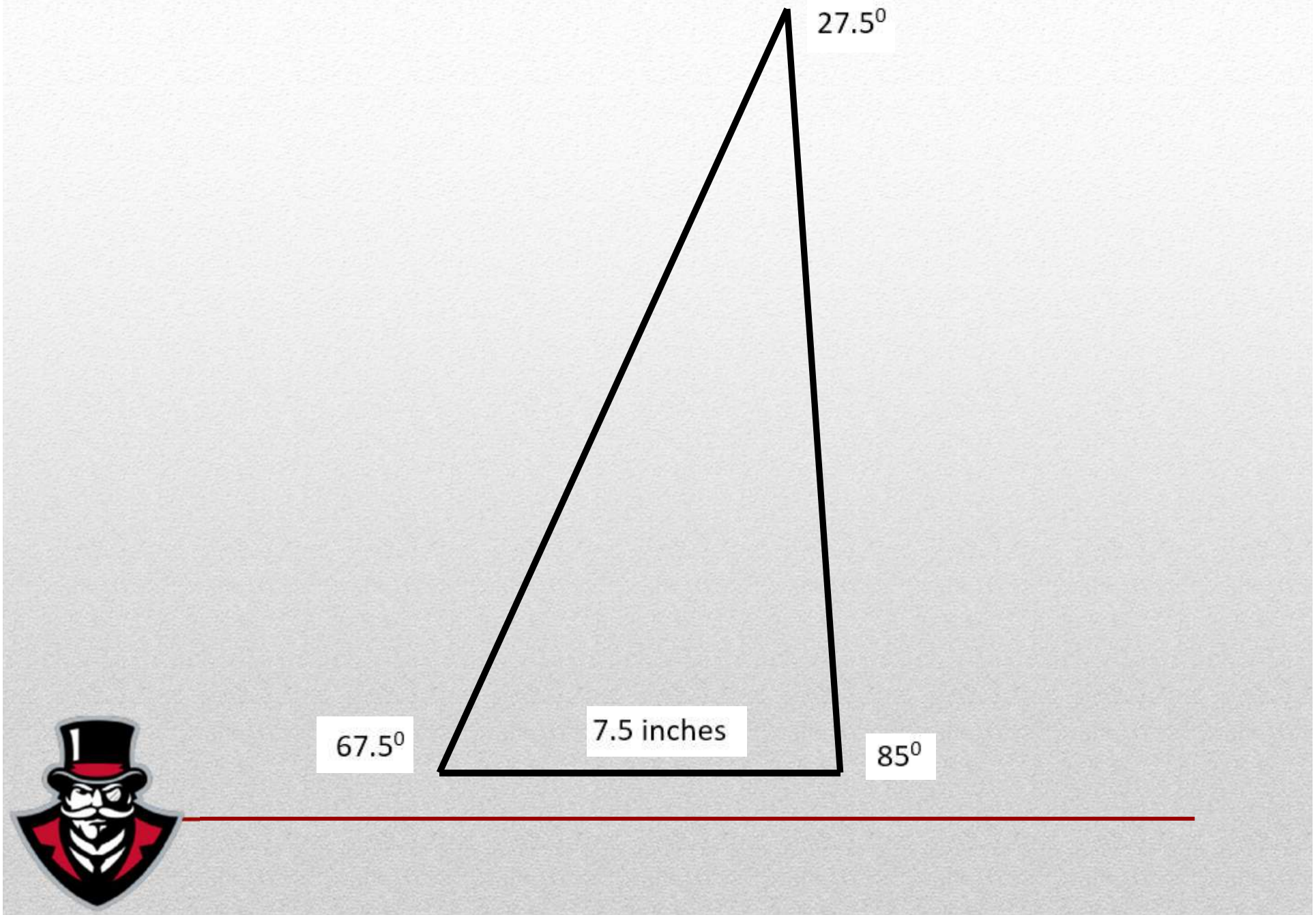
- Find the bottom two angles with your protractor.
- Solve for the top angle.
- Measure the bottom of the triangle on your bench in inches.
- Empirically solve for the two unknown sides using a ruler and your personal scale on your handout.
- Consider using cm to make these measurements.

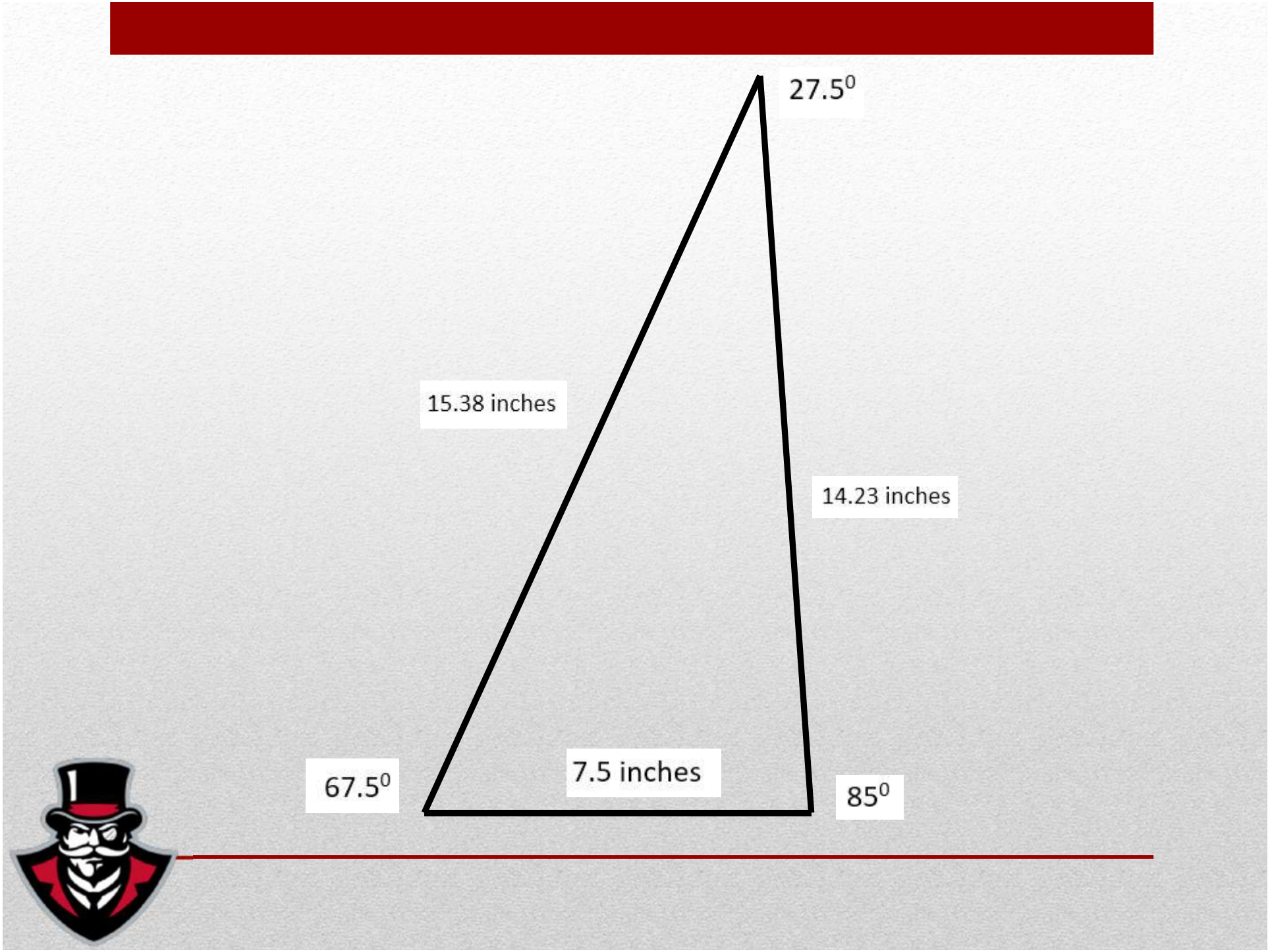


What are the bottom angles?




67.5^0
7.5 inches
85^0


27.5⁰
67.5⁰
7.5 inches
85⁰


27.5⁰
15.38 inches
14.23 inches
67.5⁰
7.5 inches
85⁰

Inclinometer resting on the arm

In closing...

- Thank you for your attendance and participation
- Thank you for what you do every day for our young people

- My business card are available. Drop me an email if you'd like a copy of these slides and your mini-bench plans
- Best wishes for a productive spring semester
- I will be raffling off these bench sets if you wish to participate please give me your ticket stub.