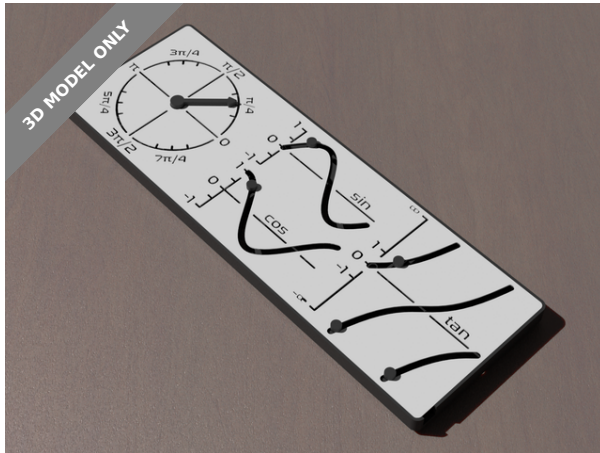




Mechanical Unit Circle and Trigonometric Functions



Devin Ho

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Summary

This is a completely mechanical demonstration of the unit circle and corresponding trigonometric functions!

[Learning](#) > [Math](#)

Tags: [small](#) [geometry](#) [circle](#) [gear](#) [mechanical](#) [slider](#) [angle](#) [math](#) [slide](#) [unit](#) [cosine](#) [sine](#) [graph](#) [tangent](#) [trigonometry](#)

This is a completely mechanical demonstration of the unit circle and corresponding trigonometric functions! Rotate the handle on the circle to a corresponding angle and watch the sine, cosine, and tangent graphs' value change with the angle, represented by a point that slides along the graph. You can also move the sliders on the graphs and see how the angle and other graphs correspond with the given value.

This is a fun print to help students understand the relationships between the sine, cosine, and tangent of angles in a visual and tactile way. Many educational math toys cannot demonstrate more advanced mathematical concepts, so I hope prints like mine can help. Especially with the increase

in online learning, this model should help students truly understand fundamental trigonometry.

The parts are designed to fit on a small 120mm x 120mm print bed so students, teachers, and myself with small printers can still enjoy the model! Assembly is also easy, with most parts sliding into place or being press-fit together (glue can be used for extra strength).

Any updates will be posted in the "Print Instructions" area.

Thanks to my friend, Alan Onuma, for printing the blue model for me after my printer broke! Also, thanks to those in the comments for feedback, allowing me to improve my design!

Cover/First Image rendered in Blender.

(For any keen mathematicians out there you may notice the tangent graph is not actually a tangent graph. This was intentional to avoid the high magnitude of slope, which would make it hard for the slider to push the point in the slot. But at least it looks like a tangent graph. The other issue is that there are two Y-Values for the X-Values where the asymptotes should be, but this is another thing I had to compromise due to space issues.)

Print instructions

PDF Version of Instructions Images. These instructions are also posted as images in this description (scroll further down).

<https://drive.google.com/file/d/1a1SECP9e5kTqXfEU5ILeGzUv6JzaH1nr/view?usp=sharing>

Parts List and Description

- 1 - Top Face Left: Top face with the unit circle markings.
- 1 - Top Face Left (Degrees): Top face with the unit circle markings. Instead of the angle being shown in radians, it shows them in degrees.
- 2 - Top Face Mid: Top face with the sine and cosine graphs.
- 3 - Top Face Right: Top face with the tangent graph.
- 4 - Slider Rack: Rack that meshes with the gears, moves the Sin-Cos Slider and Tan Slider (parts 5 and 6).
- 5- Sin-Cos Slider: Slider that moves the point slider along the sine and cosine graphs.
- 6 - Tan Slider: Slider that moves the point sliders along the tangent graph sections.
- 7 - Angle Pointer: Pointer that represents an angle on the unit circle.
- 8 - Driving Gear 10T: Gear that is directly attached to the pointer.
- 9 - Driven Gear 20T: Gear that is driven by the pointer and moves the

slider.

10 - Point Slider (Quantity 5): A circular piece that moves along the graphs.

Must print 5 of these!

10 - Point Slider (Smaller Size, Quantity 5): Same as Part 10 above but a slightly smaller size. Pick only one version to print!

11 - Point Slider Cap (Quantity 5): A press-fit ending for the Point Slider.

Must print 5 of these!

11 - Point Slider Cap (Smaller Size, Quantity 5): Same as Part 11 above but a slightly smaller size. Pick only one version to print!

12 - Base Left: Base that holds the gears and rack slider.

13 - Base Mid: Base that contains the bottom part of the sine and cosine graphs.

14 - Base Right: Base that holds the bottom part of the tangent graphs.

15 - Base Foot (Quantity 5): Feet that attach to the bottom of the bases to raise the mechanism. **Must print 5 of these!**

16 - Tan Side Base Foot (Quantity 1): Feet that attach to the bottom of the tan base. This was created because the tan indicator hits the normal foot above! **Must print 1 of these!**

Updates

1 - Fixed top left face (part 1) so step 6 works.

2 - Added two more feet from 4 to 6 (part 15), slight height modification to bases (parts 12, 13, and 14), increased size of slider pointer, reinforced tan slider with more material.

3 - Modified Parts 1, 2, and 3 such that unsupported letter/number parts are now supported. Also modified Parts 10 and 11 to be slightly larger to remove "slack" in the sliders and so they fit together better.

4 - Modified Parts 12, 13, and 14 to have a thicker bottom for more rigidity. Improved Part 6 to slide better. Completely redid instructions and part lists to look cleaner.

5 - Added Part 16 - Tan Side Base Foot such that the foot will no longer hit the tangent graph indicator when sliding. As such, you need to print one less of the "normal" foot.

6 - Added smaller versions of Part 10 and 11 in case the normal versions are too large for the sliders. Altered instruction booklet to add Part 16.

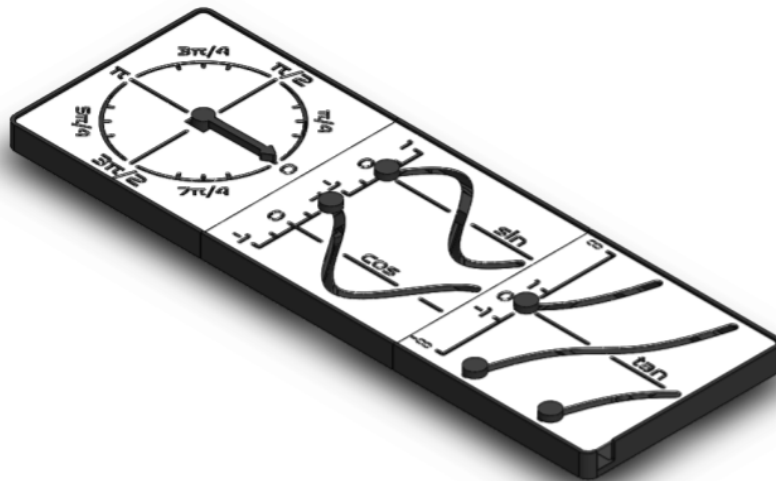
7 - Added another version of Part 1 in degrees instead of radians.

8 - (11/24/2022) Added STEP files for all the parts! If you want specific files, you can download them. Otherwise, Part 0 - Mechanical Unit Circle Assembly should have all the parts already integrated into the file and

assembled. (This was originally done in SOLIDWORKS, so importing assembly STEP files may or may not work, I'm not sure)

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By Devin Ho



Cover

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Part List and Print Orientation

Part 1 - Top Face Left



Part 2 - Top Face Mid



Print Settings

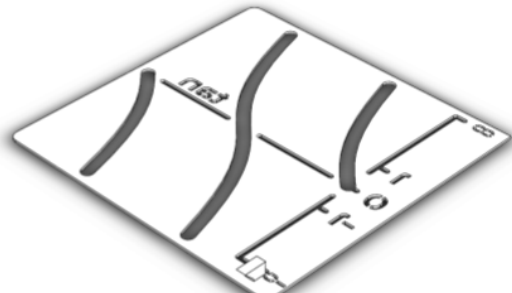
Infill: No Preference

Layer Height: 0.2 mm

Nozzle: 0.4 mm Nozzle

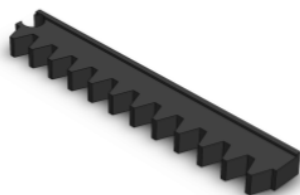
Supports: None

Part 3 - Top Face Right



Part List and Print Orientation

Part 4 - Slider Rack



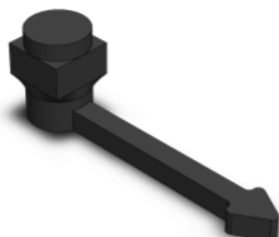
Part 5 - Sin-Cos Slider



Part 6 - Tan Slider



Part 7 - Angle Pointer



Part 8 - Driving Gear 10T



Part 9 - Driven Gear 20T



Part 10 - Point Slider
(Quantity 5)



Part 11 - Point Slider Cap
(Quantity 5)

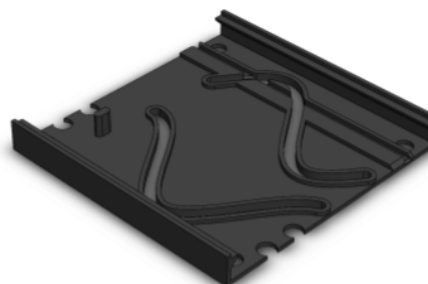


Part List and Print Orientation

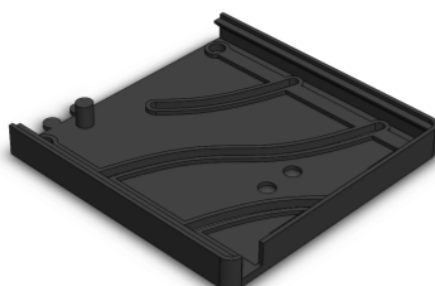
Part 12 - Base Left



Part 13 - Base Mid



Part 14 - Base Right



Part 15 - Base Foot
(Quantity 5)

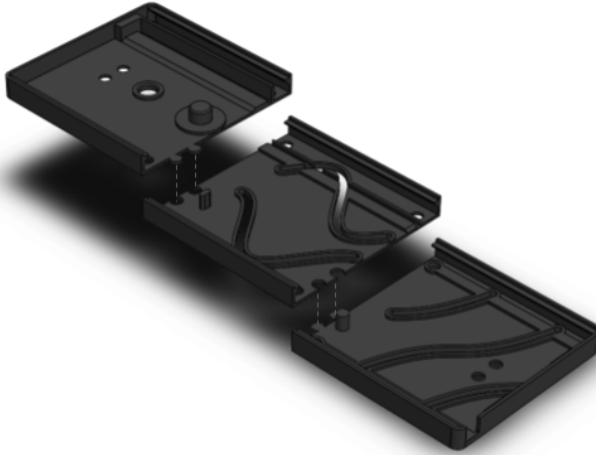


Part 16 - Tan Side Base Foot
(Quantity 1)



Step 1

Connect *Part 12 - Base Left*, *Part 13 - Base Mid*, and *Part 14 - Base* together via the circular inserts. Apply glue on the surfaces which contact each other and wait for them to dry.



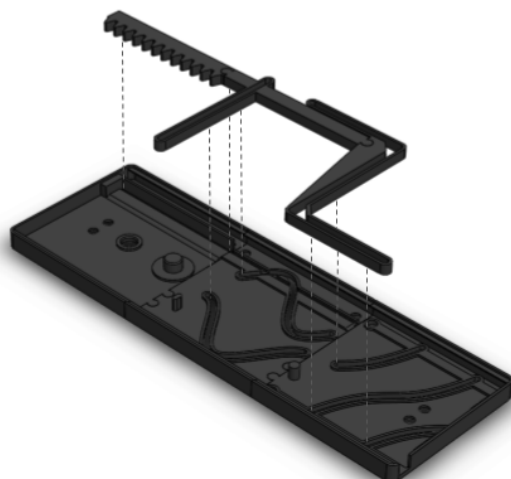
Step 2

Connect *Part 4 - Slider Rack*, *Part 5 - Sin-Cos Slider*, and *Part 6 - Tan Slider* together via the circular inserts. Apply glue on the circular inserts and wait for them to dry.



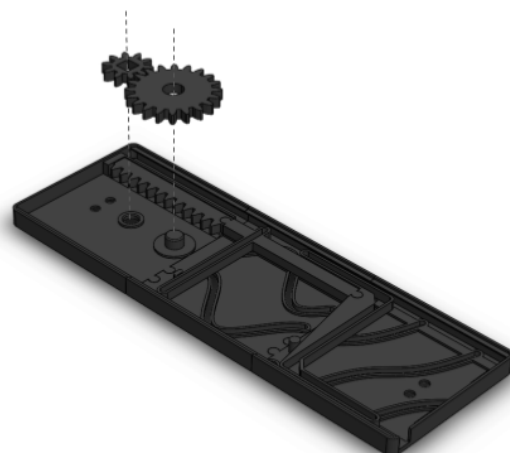
Step 3

Insert the assembly made in Step 2 into the assembly made in Step 1. Make sure that the small extrusion on the underside of the Slider Rack slides into the small slot on the Left Base.



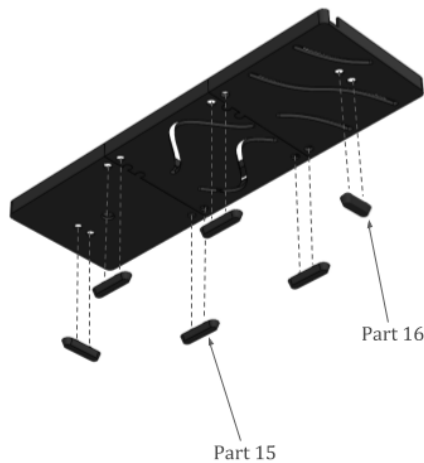
Step 4

Insert *Part 8 - Driving Gear 10T* and *Part 9 - Driven Gear 20T* onto the assembly made in step 3. Before inserting the gears, make sure the sliding assembly made in Step 3 is moved all the way to the right and that the gears are aligned such that the square insert on the Driving Gear 10T is parallel with the sides.



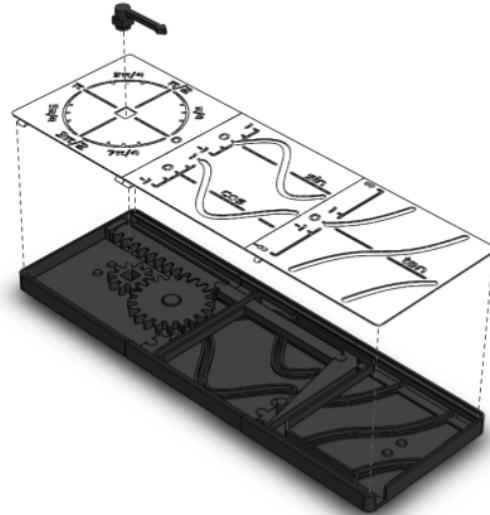
Step 5

Insert *Part 15 - Base Foot (Quantity 5)* and *Part 16 - Tan Side Base Foot (Quantity 1)* into the holes on assembly. Apply glue to the touching surfaces and wait until dry.



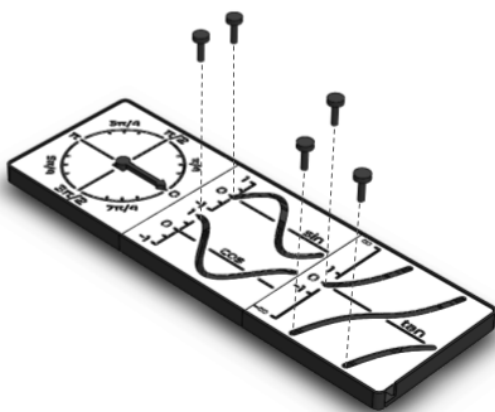
Step 6

Insert *Part 1 - Top Face Left*, *Part 2 - Top Face Mid*, and *Part 3 - Top Face Right* onto the assembly. You will need to bend the Top Faces in order to insert them on the internal rail. Shortly after, insert *Part 7 - Angle Pointer* through the Top Face Left and the Driven Gear 10T. Make sure it is pointing at 0 and the sliders are pushed completely left.



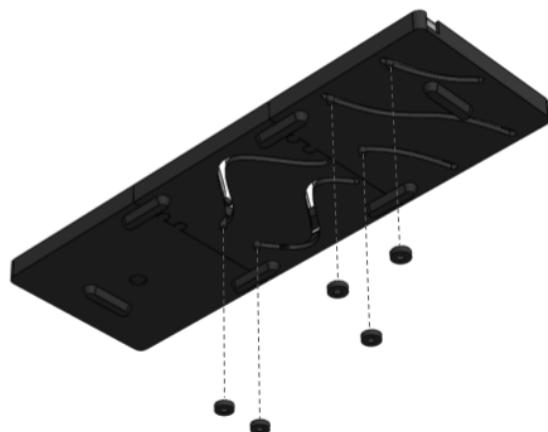
Step 7

Insert *Part 10 - Point Slider (Quantity 5)* into the graph slots on the assembly. Make sure that the Point Sliders go through the Sin-Cos and Tan Sliders under the Top Faces.



Step 8

Insert *Part 11 - Point Slider Cap (Quantity 5)* onto the ends of the Point Sliders. Apply glue to the Point Slider Cap and Point Sliders if necessary, but make sure they can still slide along the slots.



Model files



STL Files

19 files



1-top-face-left.stl



1-top-face-left-degrees.stl



2-top-face-mid.stl



3-top-face-right.stl



4-slider-rack.stl



5-sin-cos-slider.stl



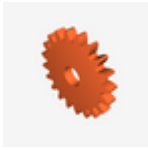
6-tan-slider.stl



7-angle-pointer.stl



8-driving-gear-10t.stl



9-driven-gear-20t.stl



10-point-slider-quantity-5.stl



10-point-slider-smaller-size-quantity-5.stl



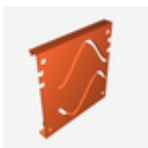
11-point-slider-cap-quantity-5.stl



11-point-slider-cap-smaller-size-quantity-5.stl



12-base-left.stl



13-base-mid.stl



14-base-right.stl



15-base-foot-quantity-5.stl



16-tan-side-base-foot-quantity-1.stl



STEP Files

18 files



0-mechanical-unit-circle-assembly.step



1-top-face-left-degrees.step



1-top-face-left-radians.step



2-top-face-mid.step



3-top-face-right.step



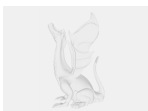
4-slider-rack.step



5-sin-cos-slider.step



6-tan-slider.step



7-angle-pointer.step



8-driving-gear-10t.step



9-driven-gear-20t.step



10-point-slider-quantity-5.step



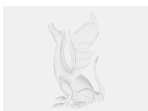
11-point-slider-cap-quantity-5.step



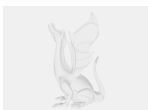
12-base-left.step



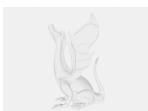
13-base-mid.step



14-base-right.step



15-base-foot-quantity-5.step



16-tan-side-base-foot-quantity-1.step

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