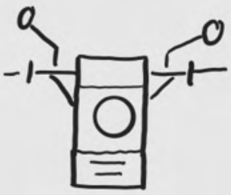


Design Fabrication Final Project

Personal notes for

Design → Prototype → Final Product

By: Matthew Ryckman

Date: 3/30 – 6/15/26

Location: OCC- Arch 171 - Design Fabrication & intro to 3D design & modeling software

Assignment: Build an item using 2 or more tools = Laser cutter, 3D printer & CNC

My project 1) custom headlight fairing for motorcycle with shield ✓ completed
2) custom box for back of motorcycle with storage + straps to hold items X Only Designed

Inspiration:

1)

Laser Cut

PLA 3D print

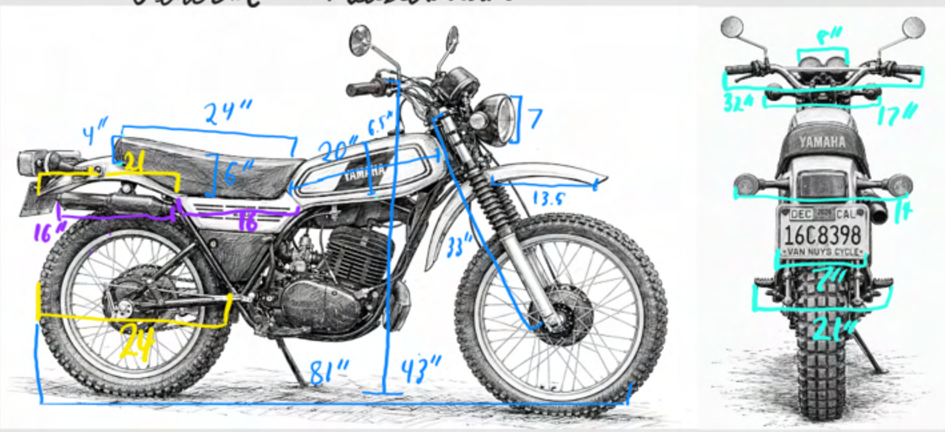
2)

Motorcycle hard luggage

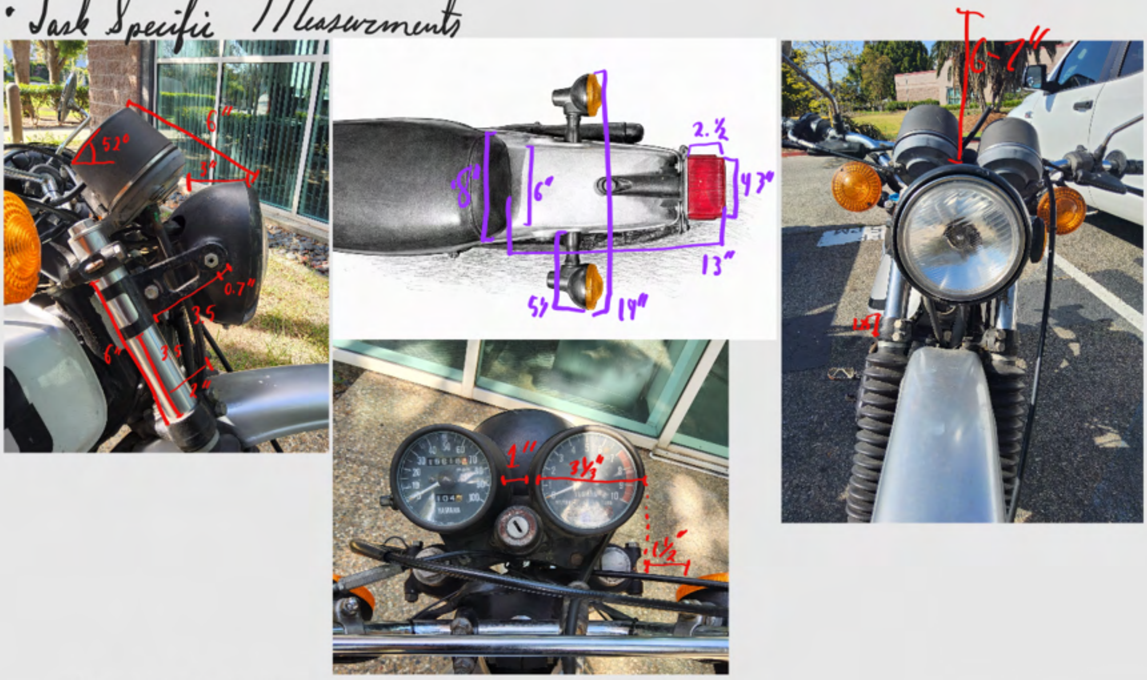
My Bike: 1978 Yamaha DT 250

Dimensions + Rhino 8 scaled motorcycle

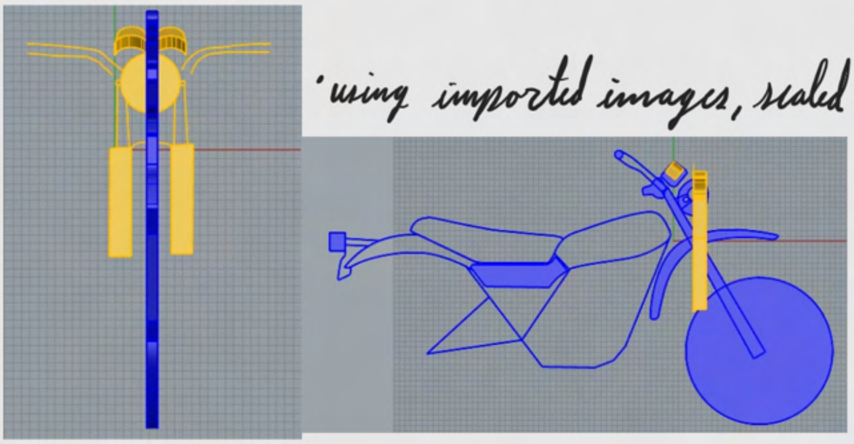
• General Measurments



• Task Specific Measurements



Scaled Rhino 8 Dirt Bike



'using imported images, scaled & traced main parts of bike

☆ Check Hard Lessons Learned (HLL) ☆

↳ @ end of notes

☆ HLL-01 ☆

Pre Build Design Work

- After Dimensions → need to decide on initial shape
  1. needs to be complemented with 1978 theme
  2. Both front fairing & back rack should work together

- Visual language
  ↳ lines, curves, proportions, angels, posture, and direction to communicate emotion

Problem: I'm an engineer not an artist dont "How to create a design that is aesthitically pleasing?"

Solution: instead of drawing shapes → cut out with scissors to get cool unique shapes

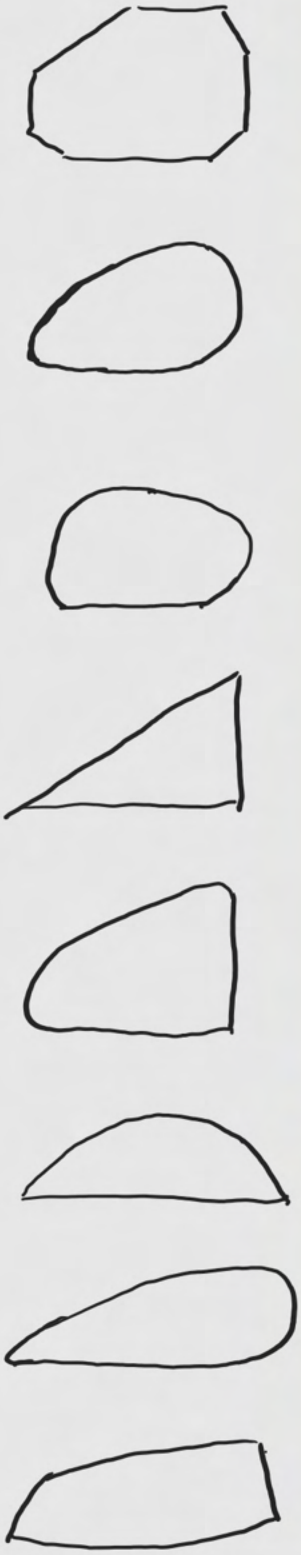
- by holding shapes up to bike to have an idea of how it will look

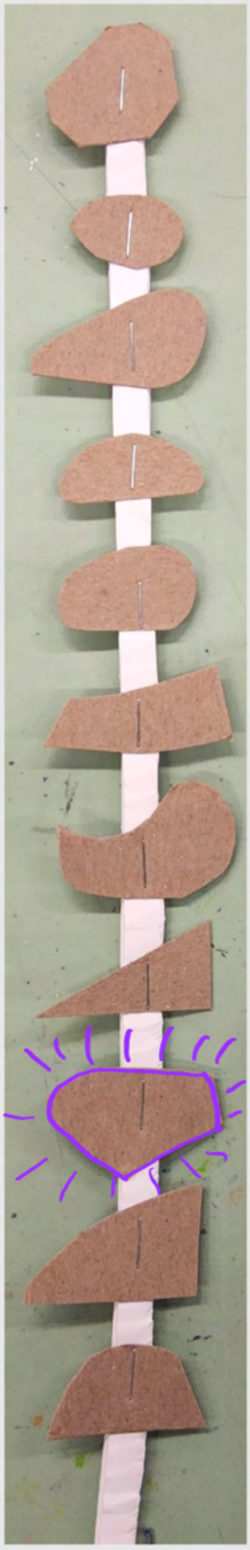
- by having all cutouts easily accessible can quickly run through different shapes

Round 1

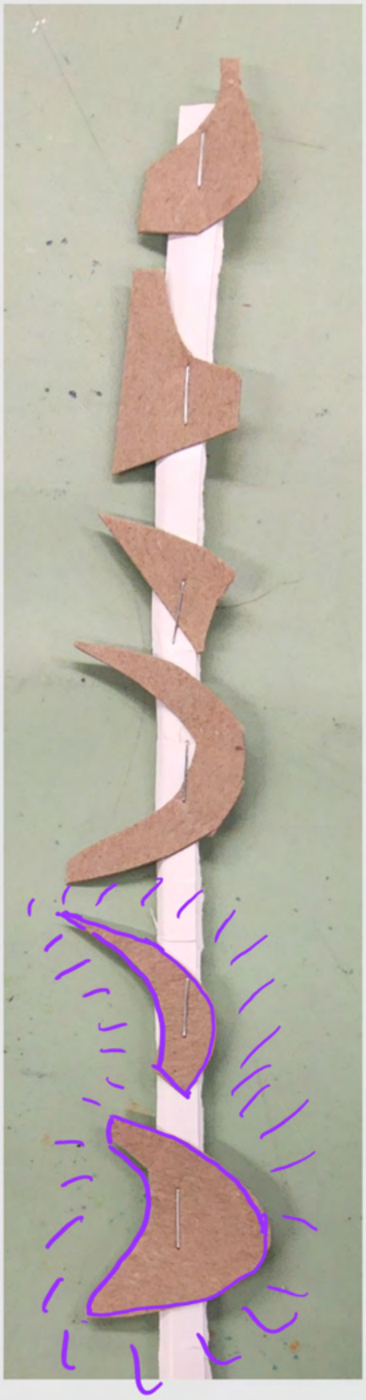
- first iteration of designs
- tested on my own first, then included classmates to see which one ppl liked = ♡ purple means design passed

Back shapes



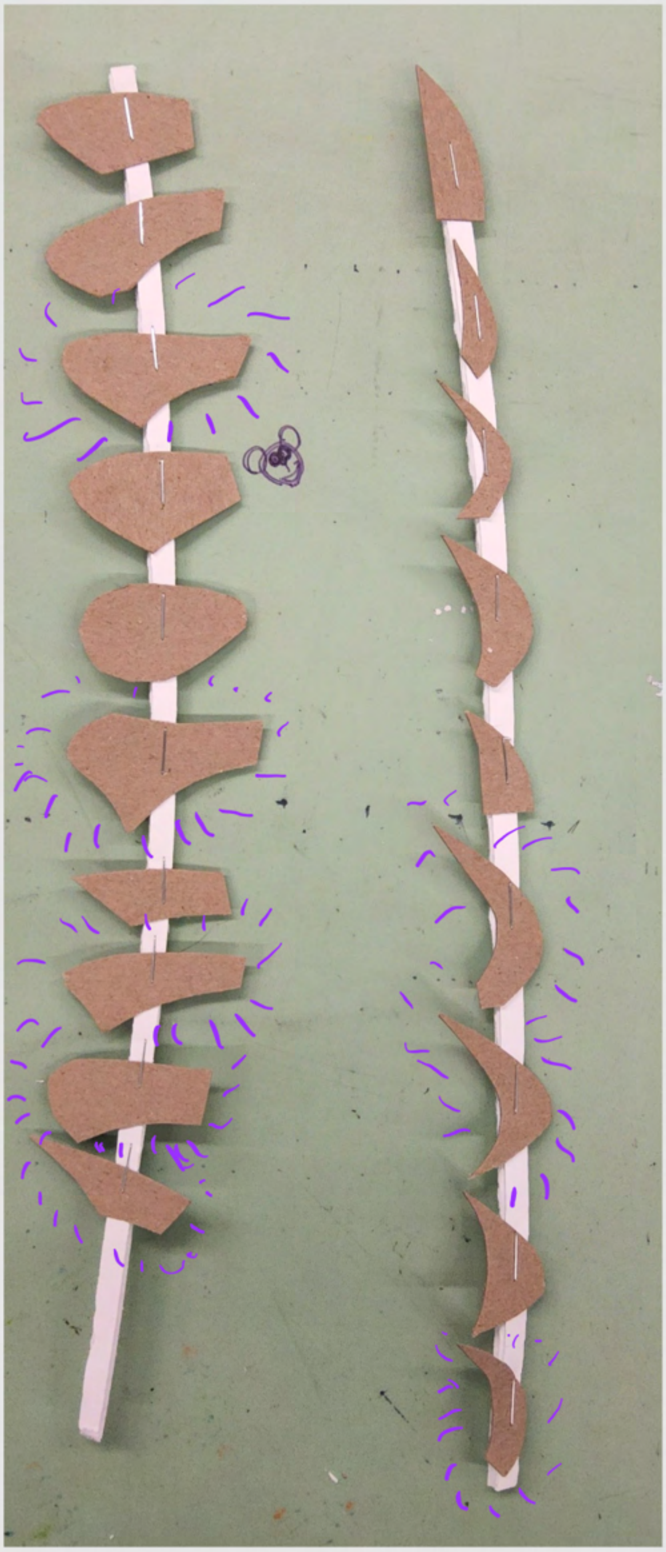


Front shapes

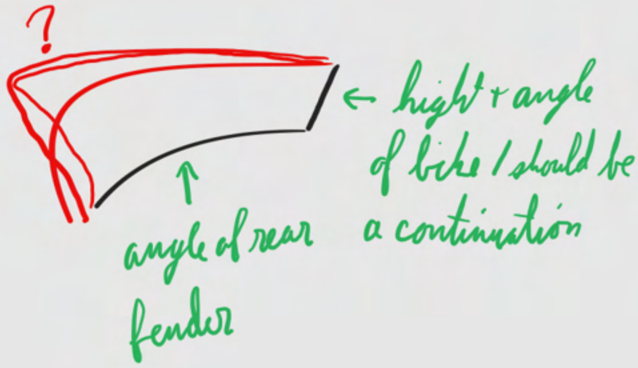


☆ Now that I know what shapes passed, round 2 will isolate the aspects I like ☆

Round 2



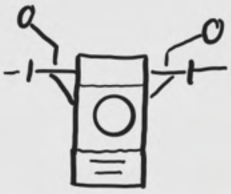
For the back



For the front

- Olyptical shape
- how far down it go
- How thick?

HLL-02



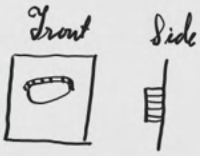
Headlight Fairing

Mount

- To create a structurally sound product need to mount on the frame or a sturdy attachment point

☆ Connecting the light to the front forks you have this unique shape

Solution One



- if I copy the shape of the structure then I can wedge a knob into the space to secure the fairing X 2

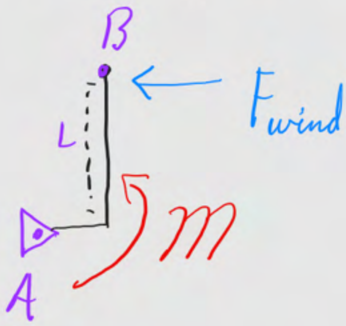
- Nothing is preventing knob from slipping out! I use a screw to connect knobs  and tighten 

= horizontally stable

Problem: Moment Force will shear off knob

A is mount point and B is end of fairing.

Force Diagram



Given: $L \geq 6''$ & Max motorcycle speed 60 mph
Assume: $C_D = 1.0$, $A = 0.05$, $\rho = 1.225\ Kg/m^3$

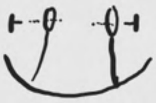
$$F_{wind} = F_{drag} = \frac{1}{2} \rho V^2 C_D A \qquad 60\,mph = 26.82\,m/s$$
$$= \frac{1}{2} \cdot 1.225 \cdot 26.82^2 C_D A$$
$$\approx 440\, C_D A$$
$$\approx 22\,N$$
$$\boxed{F_{wind} \approx 5\, lb_f}$$

$$M = L \cdot F_w$$
$$M = 6_{in} \cdot 5\, lb_f$$
$$\boxed{M = 30\, lb\text{-}in}$$

☆ all that resting on one joint ☆

Solution two

2X 

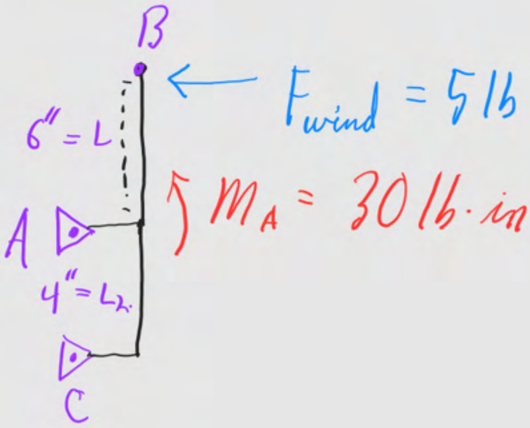


- Looking at other dirt bike fairing design found that to reduce moment they used 2 connection points

1) screw for old reflector

2) fork attachment

Force Diagram



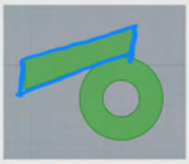
$$F_{support} = \frac{M_A}{AC}$$
$$F_s = \frac{30}{4} = 7.5\,lb$$
$$F_A = 7.5\,lb$$
$$F_C = 7.5\,lb$$

☆ Way better ☆

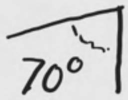
☆ HLL-03 ☆

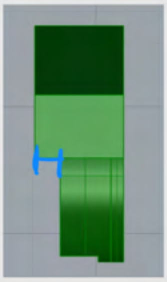
Solution 3

- Only 1 mounting location & still counter acts moment
  - ↳ solution 2 is stronger ↺ adding another connector on fairing is 2X the work
  - ↳ look at HLL-03 → not enough time

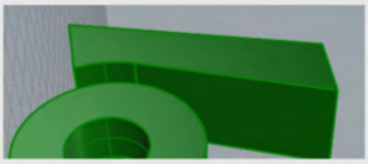


- Arm has same angle as bracket mount
- 2" long & ½" tall

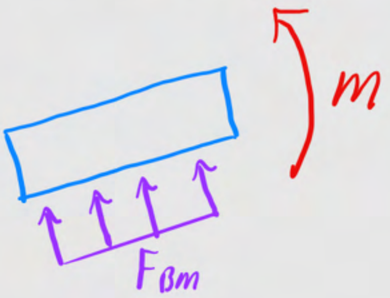




lip rests on fixed bike mount



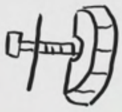
Force Diagram

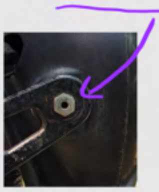


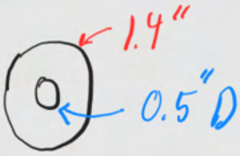
M = moment from wind

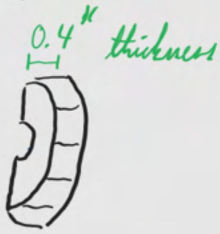
F_{BM} = bike mount

- if my mount can fit on bracket then I can squeeze my fairing onto the bike using the available screw with washer

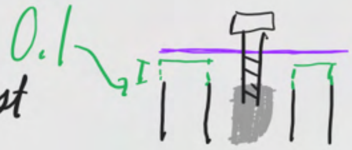






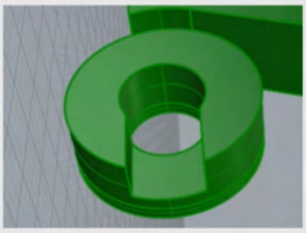


Problem: thickness can't be same as bolt 0.4

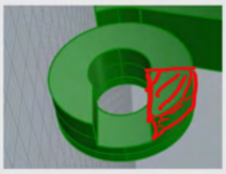
Solution: need to add material 

squeeze part against so washer can bike mount

Problem: Part is made of PLA which is ridged → if perfect fit will not be able to slide over fixed bike mount



Solution: add cut out for easy install ↓ downward

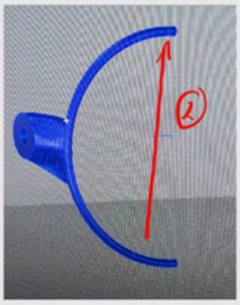


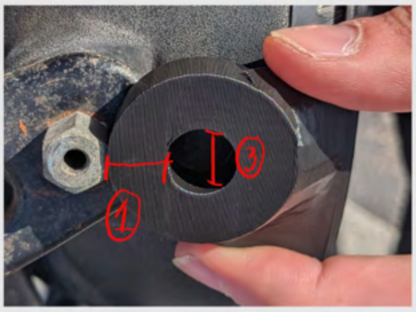
☆ in final part assembly needed to install → horizontally b/c of headlight so removed right wall as well ☆

Prototyping

Goal: develop a mount that fits bracket & holds head light cover

Round 1



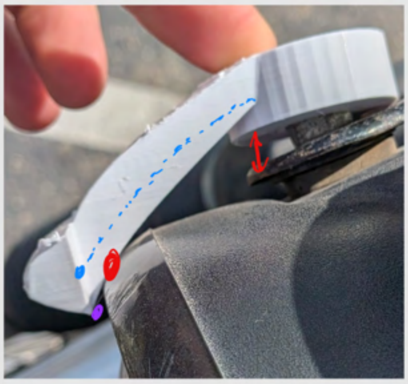


① Distance was off changed to 2.00"

② Damiter of circle was 7" changed to 6" + made thicker

③ Diamiter .5 changed to .6 for looser fit

Round 2

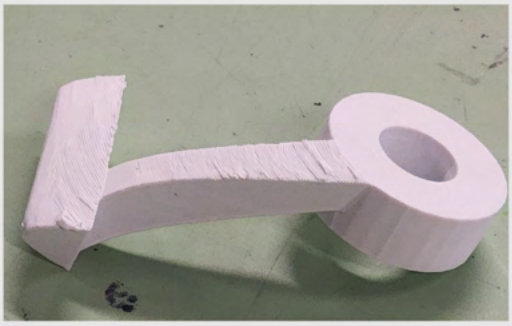


- point of contact = too close so didn't fit ↕

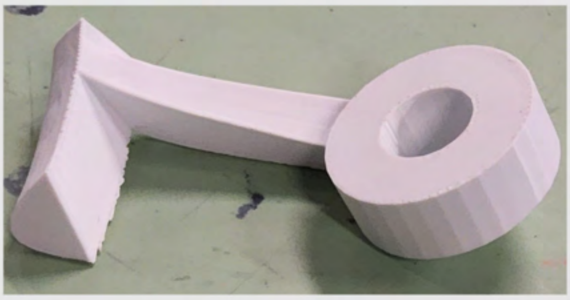
↳ instead of edge being at inner radius need to move attachment to middle to make room for light

☆ when printing/outer layer was facing down + needed supports

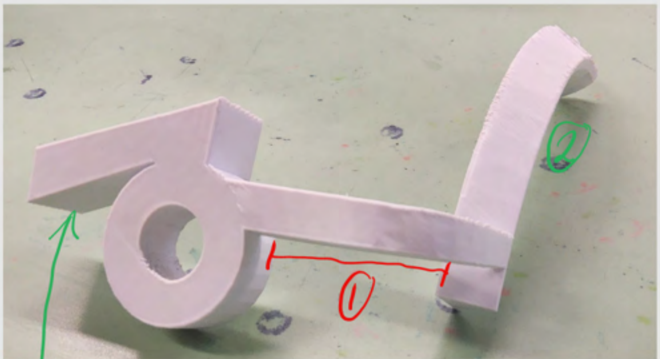
Result = Rough outer surface ⟶ on finished product outer shell should be printed facing up ☆



vs



Round 3

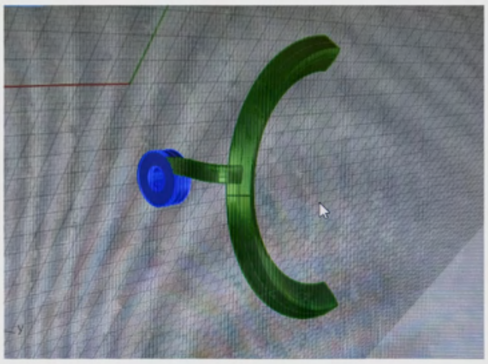


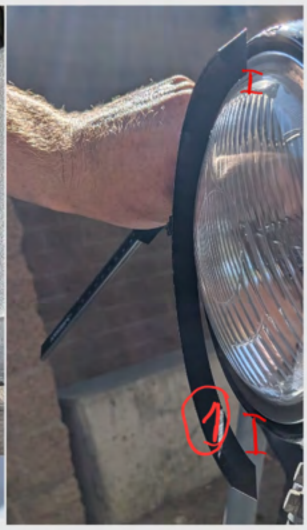
☆ Extra support against moment from wind force

① distance off by 0.2 mm

② new circle shape is thicker + bigger = look better

Round 4





① Diameter of circle still too large + not centered on light

☆ Before V.4 only printing 1/4 of circle for speed ↳ couldn't see not centered

↳ move center circle ↑ 0.38"

② Length + 0.2mm ✓ distance for circle around light is good now

☆ Need to move on in construction so added buffer material + ↑ spacing, risking a looser fit ↳ a product I can use. ☆

Next Steps

I have the spacing from the mount to the headlight + strong enough bracket to resist moment ✓

⇓

- Need to build
  1) dash
  2) Windshield + supports
  3) connection between dash + mount

Dash - covers open spaces between Speedometer + RPM gauges

↳ Use laser cutting for quick turn over + get tolerences right

- starts off @ 3.27 diamete = too small
- Top part way too big

- Diamete 3.75 = too big ✗
- middle part should be an inch ✗
- Hight is good + shape ✓

★ make it wrap all the way around ★

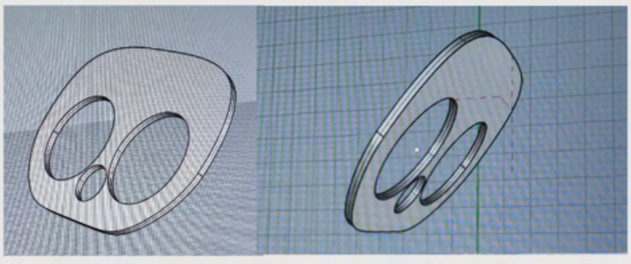
- Diameter too small = 3.500 → 3.6
- Key hole lower + little bigger = 1.42 ↓ 1.5
- b = too big

- Bottom + top = ✓
- Key = ✓

★ for later ¿do I want a tight fit? 3.5" Diameter

¿do I want loose to account for vibrations? 3.6 D

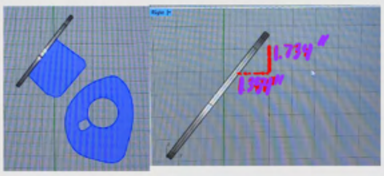
In Rhino



★ HLL-04 ★

Wind Sheild + Supports

- from top of dash would like 6"-7" windshield



- Dimension = space between speedometer + top of Bracket

- for strength + stability going to laser cut a polyester for shield
  - ↳ problem is Laser Cutters only print in 2D

= from

to

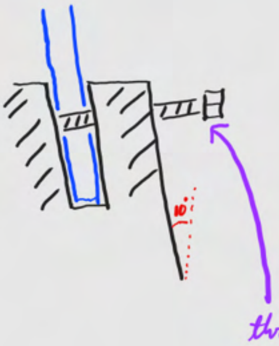
- Change shape from round to square

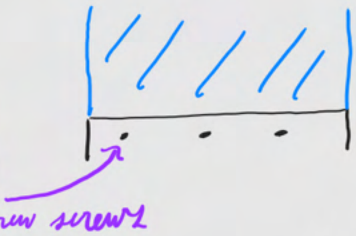
or

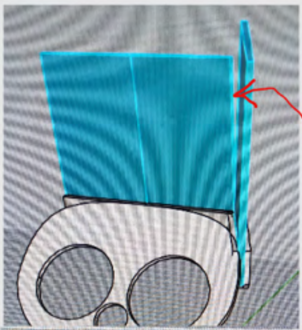
- with a sweep to go from

Round to smooth + elevation change

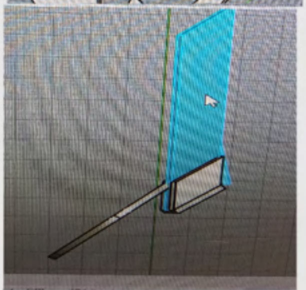
- to hold shield need a channel >1.735"
  & @ 10° angle + pockets for



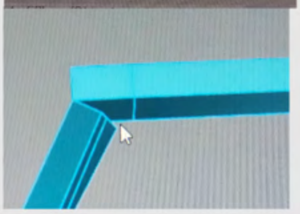




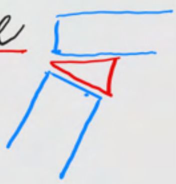
Problem: B/c of angle in glass on front windshield angle in foundation for side windsheild there is a seperation I need to fix



Solution = first build side windsheild @ angle → then supporting structure



B/C of angle going to have some space in between panels = ★ glue or silicone sealant



★ Required fits ★

1) Bracket → headlight ✓
2) Dash ✓
3) ?? Dash → Bracket ??

Prototyping – needs to be 3D printed ∫ time is @ high priority

↳ center line test = make sure dash is in middle when attached to Bracket

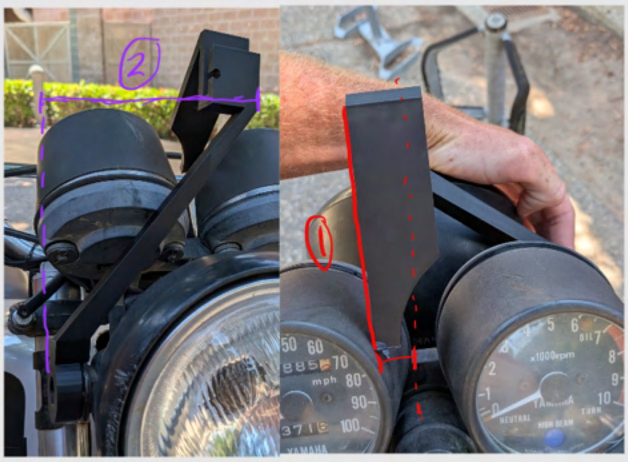
★ print as little as possible to get needed information ★

Wind Shield channel

from Center line to speedometer edge

Bracket

Round 1



① This is supposed to be in the center of the speedometer

② Original distance from center line 7.464" VS after double checking measurement should be 6.82" → b/c HLL-01

Round 2

★ Perfect fit ★
↳ all required fits = Done ✓

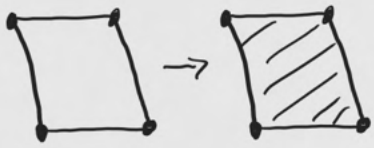
Skeleton

↳ with Dash, Windshield Mount, Bracket, + Headlight covers all positioned properly I can now connect all pieces with polylines

- By using gumball in Rhino, I can adjust each controle point on every line
- Started at center line & built skeleton for one side then mirrored

Skin

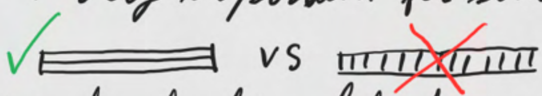
- using NetworkSrf turned 4 lines into a surface
- Extrude each surface by .25" for thickness



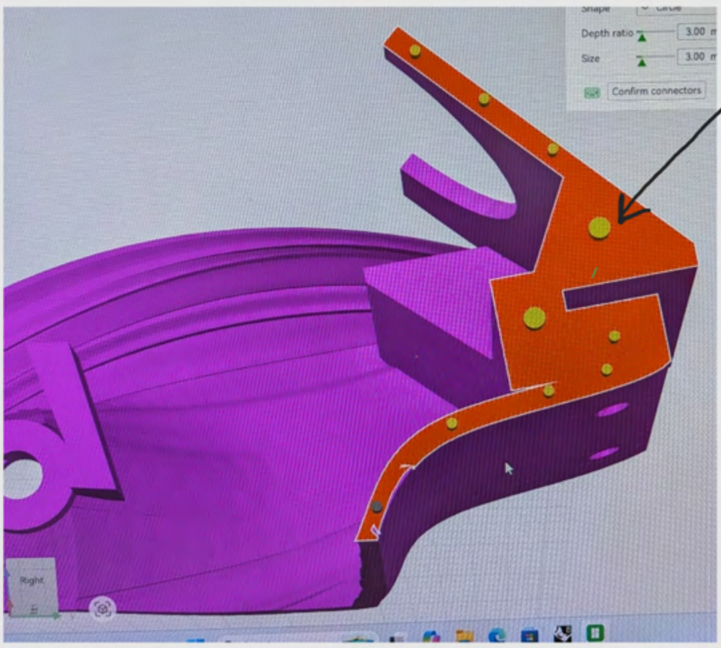
3D Printing

- Exported out of Rhino as STL and into Bamboo Lab
- B/c part is so large used Bamboos split feature to divide part into printable pieces

↳ very important for structural integrety, direction of print



↳ also locations of high pressure (mirror bracket) needs to be printed with bracket so its one piece ✓



Connectors to help parts fit / stay together

Shrinkage = 100.24%

↳ as part cools, material shrinks

- printed ½" square & found −0.0025" off from expected size

★ HLL-05 ★

Assembly

Problem: Even though I calculated shrinkage connectors still didn't fit exactly
↳ also most connectors were too small + had too many

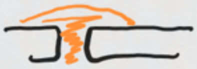
Solution: Broke many connectors off + a lot of sanding

Supporting Structures

Problem: Structural integrity / connectors came out very small & I needed to break off more connectors than I wanted to

Solution: Hot Staples were embedded across the seams = mechanical reinforcement

Caulk

↳ to make sure outersurface is flat; fill gaps  with clay-like material then sand finish

Process: → Caulk → Sand → inspect → (repeat)

Problem: Caulk only helped smooth seam between parts

Solution: First layers of paint = Automotive Filler Primer
↳ smooth entire part

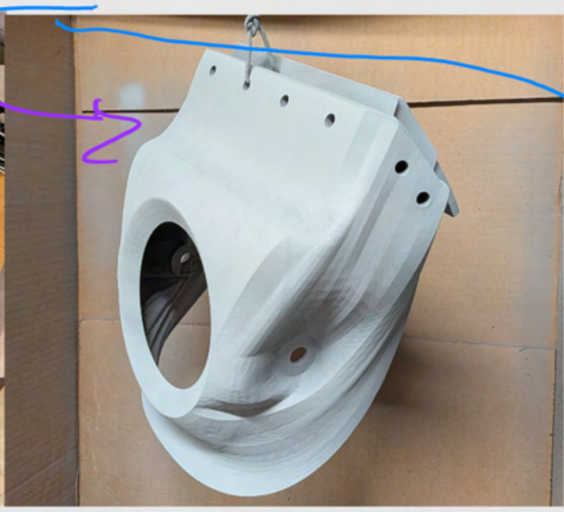
Paint

↳ Spray paint easiest to evenly cover complex surface

☆ Paint Studio ☆

First 2 Layers = Rust-Oleum Automotive Filler Primer

Top Coat = Rust-Oleum Automotive Enamel Gloss Black



Hard Lessons Learned (HLL)

HLL-01: Accurate Dimensioning Defines the Entire Design Process

The first major step in this project was establishing the dimensions of the motorcycle so the design could be modeled in Rhino 8. My original approach was to take general measurements with a tape measure and use one known dimension to scale reference images of the bike. However, this created problems because photographs distort depending on camera angle, distance, and perspective.

As a result, much of the design was based on semi-accurate measurements. Once the parts were brought into the physical world, small errors became significant. In real assembly conditions, even a 2 mm difference can affect fit, alignment, and functionality. This led to additional prototyping, rework, wasted material, and lost time.

The main lesson learned is that accurate measurement must come before detailed design. Future work should begin with a stronger understanding of the design space, fixed constraints, mounting points, clearances, and part interfaces. Instead of relying on scaled photos, I would use more precise measuring tools, such as calipers, and verify all critical dimensions before modeling.

Engineering takeaway: Measure twice, define the constraints early, and do not build a design around approximate geometry when physical fit is critical.

HLL-02: Function and Constraints Should Lead the Design Language

Early in the project, I spent about a week studying visual language and imagining what the final design should communicate. I focused on the shape, style, and emotional impression of the bike. This was interesting and useful from a creative standpoint, but it contributed less to the final outcome than expected.

The issue was that I was refining the appearance before fully understanding the construction process. Once fabrication began, the real constraints of spacing, mounting, alignment, clearance, and functionality became the main drivers of the design. In many ways, the final shape developed naturally from the physical requirements of the project.

The saying that applies here is **“don’t major in the minors,”** meaning I spent too much time on details that were not yet important. Another engineering version would be: **form should follow function**.

Engineering takeaway: Define the functional requirements, physical constraints, and build process before spending major time on aesthetics. Visual design matters, but it should be developed after the core engineering constraints are understood.

HLL-03: A Stronger Design Is Not Always the Most Practical Design

One of my original design goals was to create a two-mount system. From a force perspective, this seemed like the better solution because it would reduce the load on a single connection point and resist the wind-induced moment more effectively.

The mistake was that I became too fixed on this idea. I was convinced the fairing needed two mounts, so I spent too much time trying to make that solution work instead of stepping back and asking whether there was a simpler way to solve the same problem. Once I began building the system, the spacing between the mounts became difficult to control. Small alignment errors made the second connection point hard to position accurately, and the design became more complicated than the project timeline allowed.

Simplifying the system to a single mount ended up being the more practical solution. It allowed me to focus more attention on one accurate fitting, reduced the installation to two bolts instead of four, and created a cleaner feature that became part of the final design identity. In the end, the simpler solution was not a compromise as much as a better fit for the part, the user, and the build process.

Engineering takeaway: A design that is stronger in theory is not always better in practice. The best solution has to balance strength, accuracy, ease of installation, and the reality of how the part will actually be built.

HLL-04: Design the Assembly, Not Just the Part

I originally designed a front dash that would fully enclose the speedometer, RPM gauge, and ignition key. I used the laser cutter to prototype the dash layout and confirm that the gauges and keyhole would fit. From the perspective of the dash alone, the idea seemed workable.

The mistake was that I was too focused on solving that one part of the project. I was thinking about the dash as an isolated piece instead of thinking about how it would fit into the full fairing, connect to the bracket, and install onto the motorcycle. Even if I had made the enclosed dash accurately, it still would have created a bigger problem because the rigid shape would have blocked the fairing from being installed as one complete piece.

This changed the direction of the design. By only covering the top half of the gauges and leaving the bottom more open, the dash became easier to install, adjust, and integrate with the rest of the fairing. The lesson was not just to prototype the interface, but to understand the entire assembly sequence before committing to a closed design.

Engineering takeaway: A part can work by itself and still fail in the full assembly. The design has to account for access, installation, connection points, and how every piece fits together before the final shape is locked in.

HLL-05: 3D Print Constraints Affected Part Splitting, Surface Quality, and Fit

The final part had to be split into multiple printed sections because it was too large to print as one piece. This forced me to think more carefully about where to separate the geometry, how each section would connect, and how much structural integrity would be lost by dividing the part.

Print orientation also became an important design decision. The side facing upward generally produced a cleaner surface finish, while downward-facing surfaces had a higher risk of rougher print quality from supports and overhangs. Because of this, I had to balance surface appearance with strength and the location of connection features.

The biggest issue came from the joining tabs between printed sections. I printed a 10 mm test box to estimate dimensional shrinkage, but the tabs still did not fit as cleanly as expected. I added many small tabs for stability, but this created more fit-up problems because each tab needed sanding or adjustment after printing. In the end, a few larger tabs would have been easier to control, stronger, and faster to finish than many small ones.

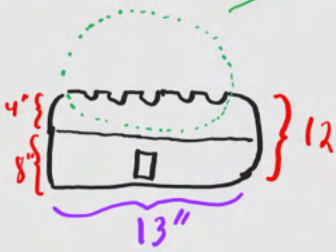
Engineering takeaway:
When a 3D printed part must be split into sections, the connection features need to be designed around printer tolerance, shrinkage, sanding access, and assembly time. Fewer, larger tabs would have been more practical than many small tabs that required individual fitting.

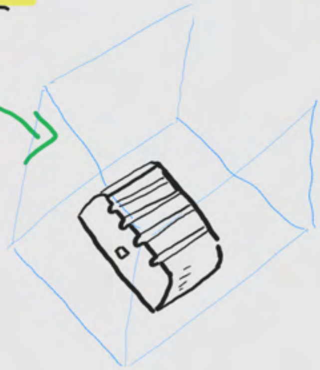
☆ Second Project ☆

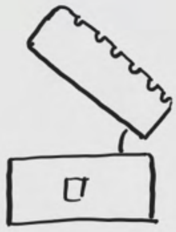
↳ not completed as course terminated + ran out of time

Back Rack

Opens !!







Water drain

☆ I want to be able to be able to hold my wetsuit so need to be able to drain water from inside the box

→ hydrolic to keep top open

Buy from amazon

Straps

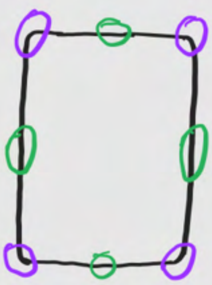
☆ on top of my box I want to have places where I can attach an elastic net + ropes

+

needs to be →| |← thick enough to hold ~2 lb

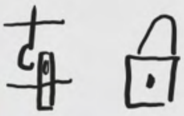
thinking 2-3 cm

4x



4x

Latch



☆ Taking insperation from YETI Silicon latch

- Rod comes all the way from side

so at least 6"+ should fit latch

- get bottom groove  dimension from actual yeti

Internal of box

X not going to be used

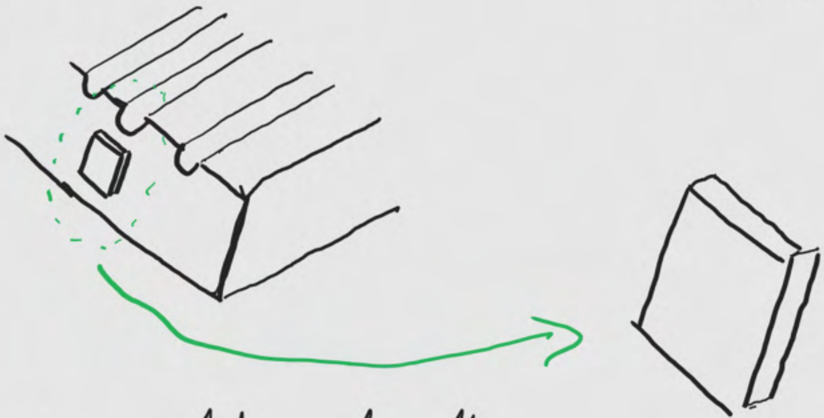
top should have netting 2nd compartment for phone + wallet

Strap excess holder

☆ You never know when straps will come in handy

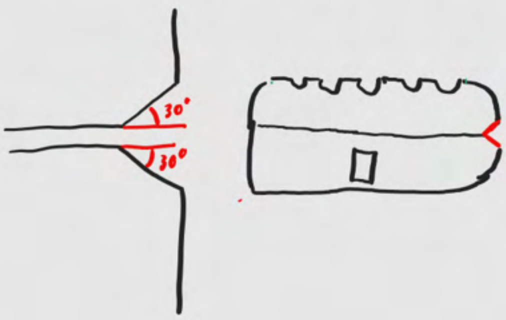
↳ container to hold straps outside of box
+
holds excess when in use

Dimensions



Open

☆ the right side of box needs to be angled so it will open

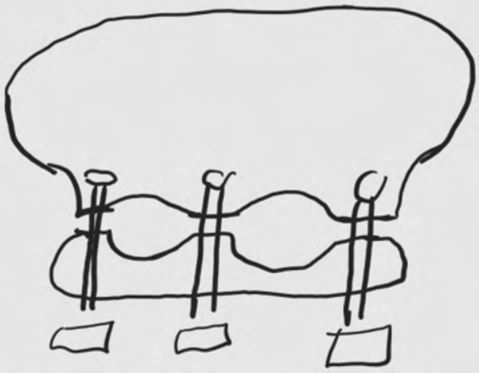


or

☆ hinge mounted on outside

Back attachment

★ to attach rack to motorcycle

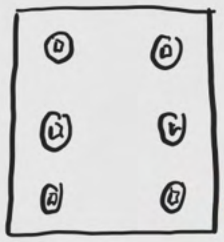


· inlay so bolt are below bottom

· screwz go through bottom of box

· should have caps to cover boltz

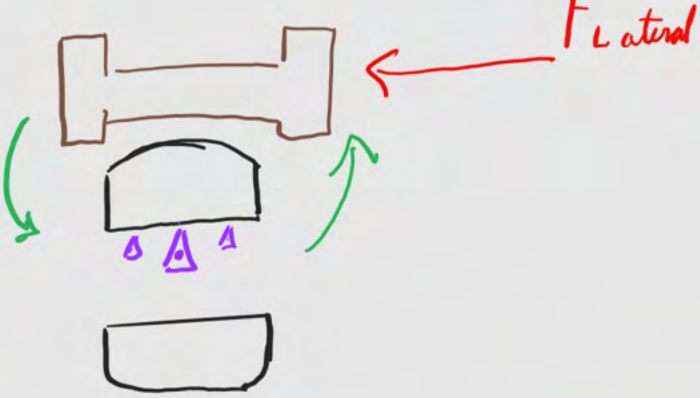
Top view bottom section



← radius = Radius of O - 0.01 in

★ snug fit ★

Problem = if straps attach to top of box & I want to strap down something heavy any lateral force will go directly on joints.



Δ = fix point from latch + hinge

★ Need to either move attachment points to bottom or reinforce box to withstand lateral forces

1) if I move latches to bottom & I have a bag I will not be able to open box without untying bag

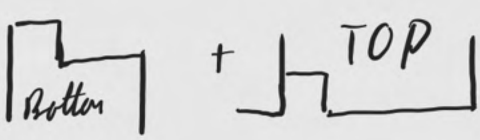
↳ if at bottom = could break if dropped  = should be in middle ⊣

2)  • make the connection between top and bottom angled so

F_L is split into 2 reaction forces. Not as much strain on joints

3)  • put stronger latches on sides to make the connection between bottom + top stronger

Solution: Simplicity is Key so solution 1 + solution 2

- move strap attachment to middle bottom section
- make connection 

Rubber

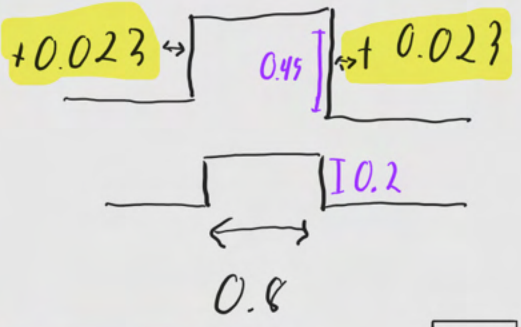
★ plastic on plastic will vibrate so need rubber or like on a yeti ★

my rubber
- width = 0.59"
- hight = 0.311"

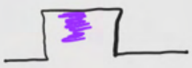
ex

Tolerence testing

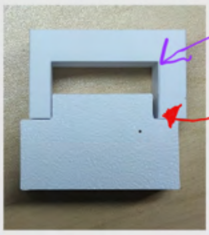
Box = connection groove between top & bottom of my box



Test Rubber fitting in connectors ¿ how much will it smoosh?



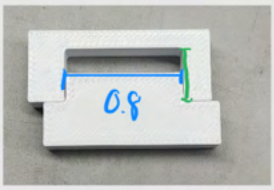
Prediction = 0.25" ✗
= 0.17 ✓



too Big + too large

V.2

± 0.05 ✓
0.37" ✓



Bottom : hight 0.2" width 0.8"

Top : 0.37" ✓ 0.8" ± 0.05 ✓

Rhino

- Project could not be completed due to limited time + availability of 3D Printers with other students :(