

# Instructions

## How to Build and How to Use

### Notes

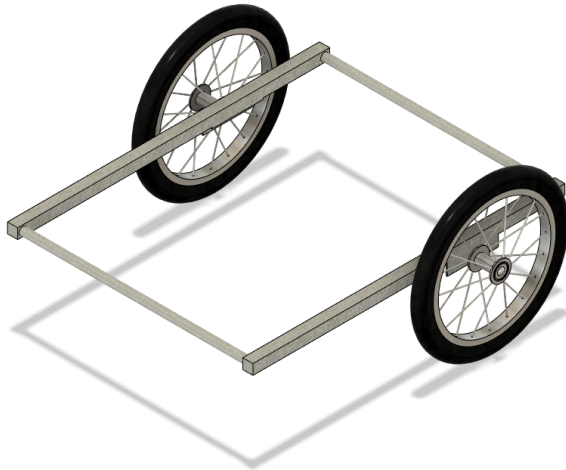
- All dimensions were originally in inches (as denoted by ["] or [in] but the conversion is given in centimeters [cm]). 1in = 2.54cm
- This document is meant to outline the steps we took to build the prototype trailer assembly. Some aspects are expected to change to suit the final use case. Possible changes include:
  - Adjust the size of the trailer frame to fit the crates that are available to hold the produce. We used 3 crates with dimensions 15.5" wide x 23.5" long x 9.5" tall (39.37cm wide x 60cm long x 24cm tall), stacked on top of each other.
  - Design the part to attach to the bike to fit the bike that will be used.
  - The frame could be made of steel for a longer-lasting trailer, with the pieces welded together. We used wood because it was quick and easily available to us.
  - Change the location of the eye hooks to more easily access them (currently it is difficult to latch the hooks on because they are behind the wheel protectors)
  - The shade frame is also a bit difficult to take on and off the trailer because it needs to be lifted above the stack of 3 crates. This could benefit from a new design idea.

## How to Build

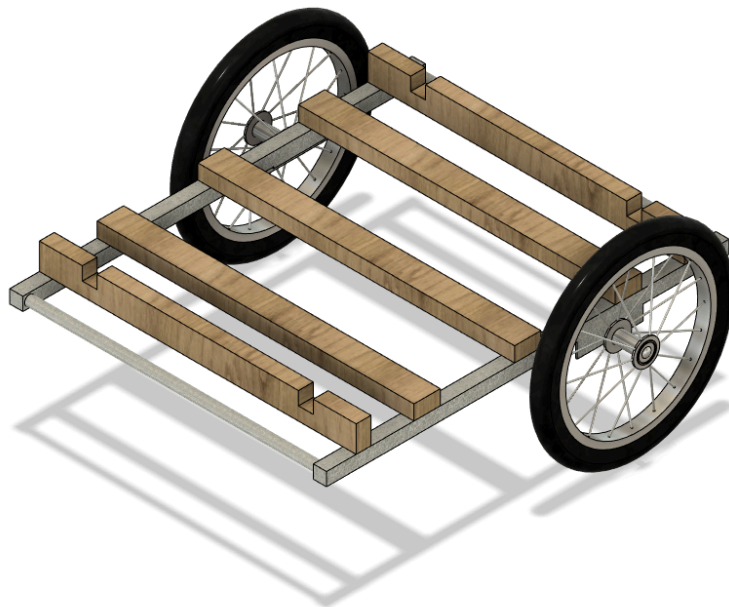
### Trailer

We started with a pre-built trailer base frame that we modified. The trailer frame was 24" wide by 30.5" long (60.96cm wide x 77.47cm long) with 2 wheels located at 9" (22.86cm) from the back. It connected to the bike on the bike's back wheel axle. After obtaining the materials, we followed these steps to build the trailer frame:

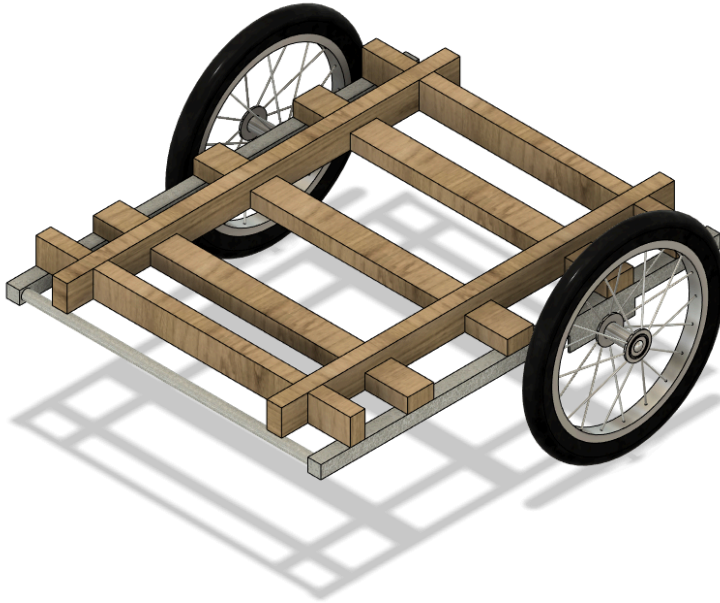
1. Build or buy a small trailer that can attach to a bike.



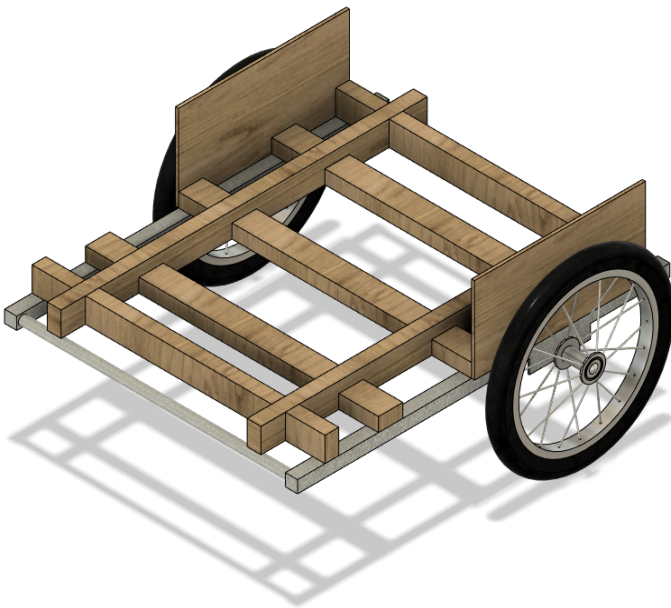
2. Cut the wooden pieces to size according to Trailer Frame Drawing - some have slots to fit into each other.
3. Bolt the 3 cross beams and the 2 front/back into place according to Trailer Drawing.



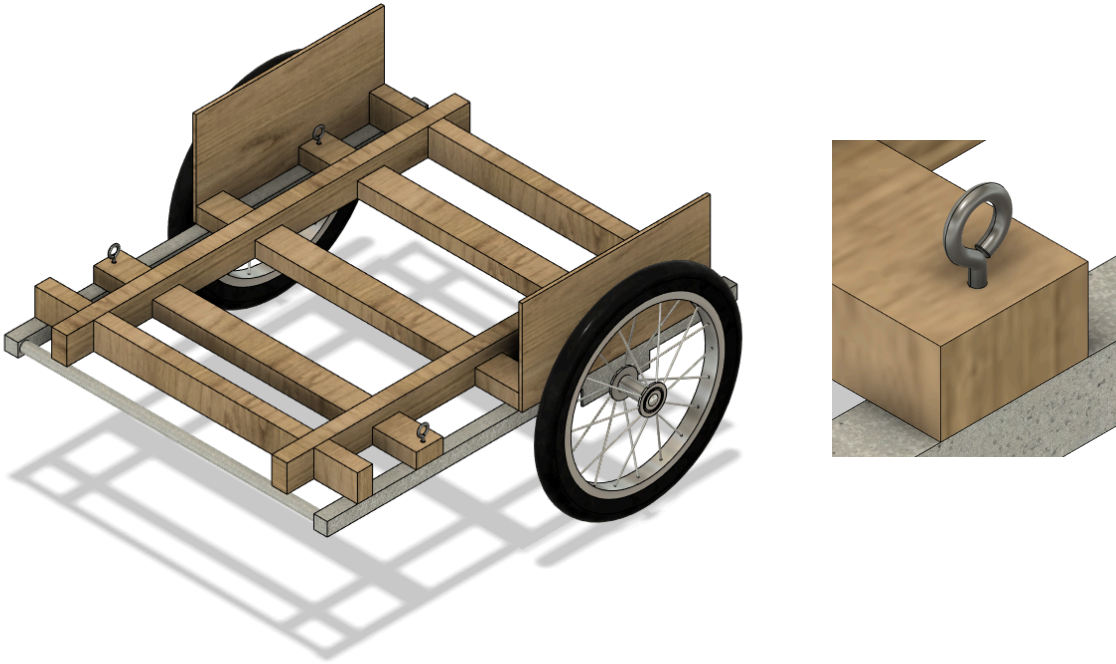
4. Fit the 2 Right/Left beams into place and screw them into the other wooden pieces.



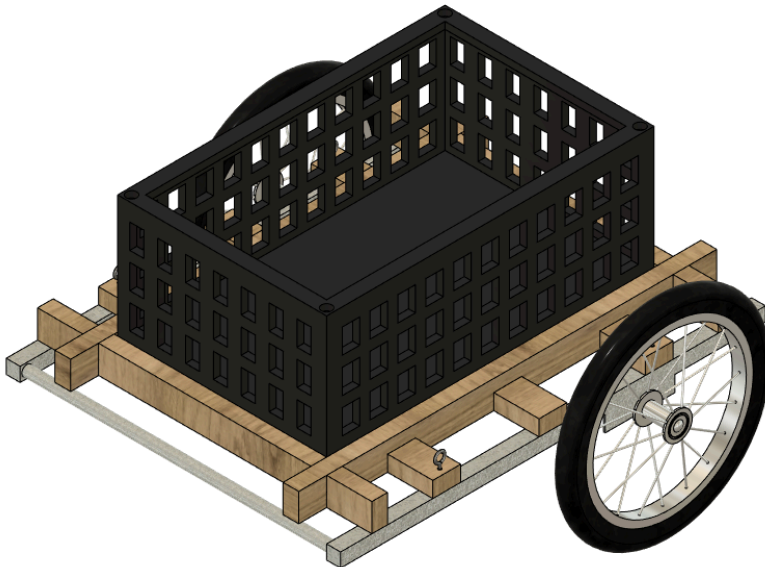
5. Screw the 2 Wheel Protectors into the sides of the middle cross beam and the back beam. This is to prevent the jute sack from getting caught in the wheels when moving.



6. Screw in eye hooks into the first and last cross beam in the centers of the beams and  $\frac{1}{2}$ " (1.27cm) from the edge.



7. Ensure the crates easily fit into the frame without much wiggle room.

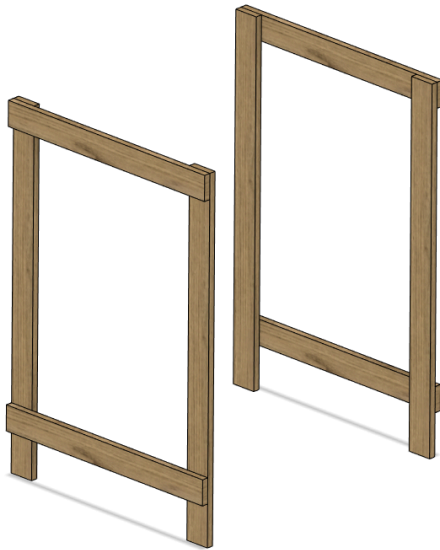




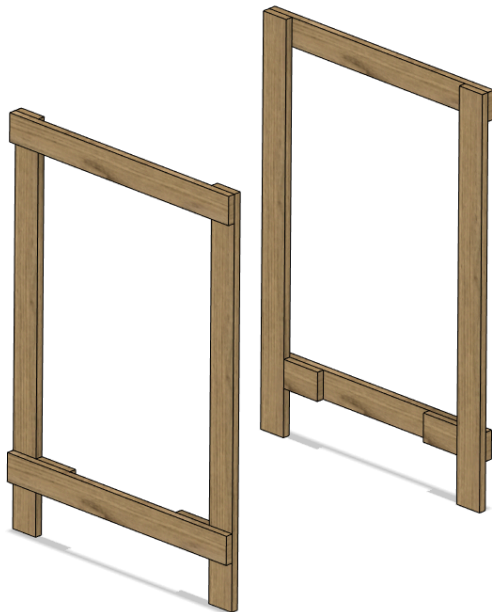
## Shade Frame

The shade frame is a removable piece to protect the produce from the direct sunlight. It was designed as a frame with 2 awnings, and can fit over and clasp to the trailer frame. It was made with wood, metal 90 degree angle brackets (some bent to 135 degrees), and shade fabric. We used 20 brackets total - 12 at 90 degrees, 4 at 135 degrees, and 4 more at 135 degrees but one leg was cut in half.

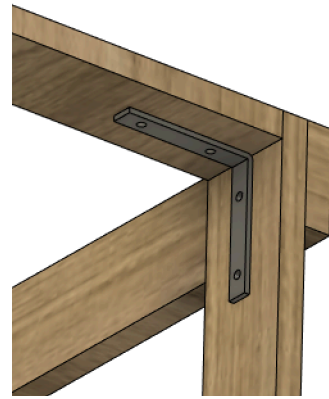
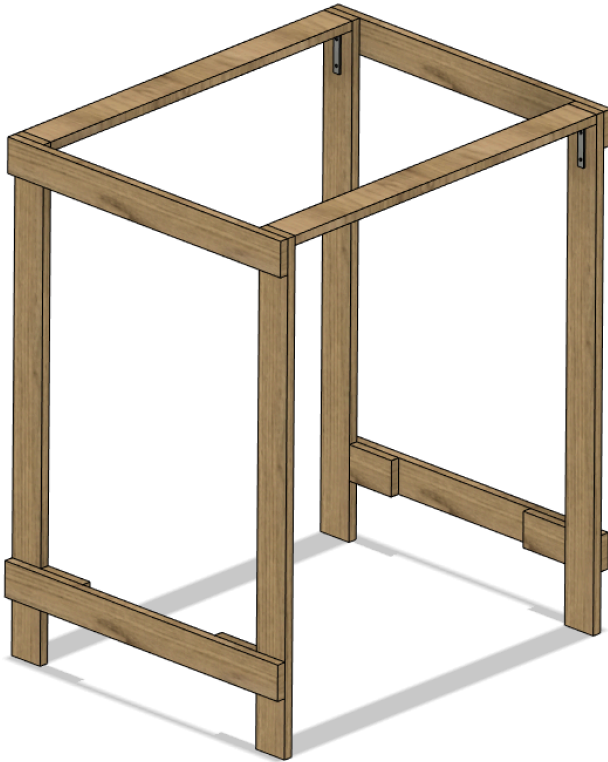
1. Cut the pieces to size according to Shade Frame Colored Drawing. The colors are just to show which pieces are identical.
2. As two separate assemblies, screw the 22 ¾" (57.79cm) long pieces directly to the 34" (86.36cm) pieces - one at the top and the other 4" (10.16cm) from the bottom.



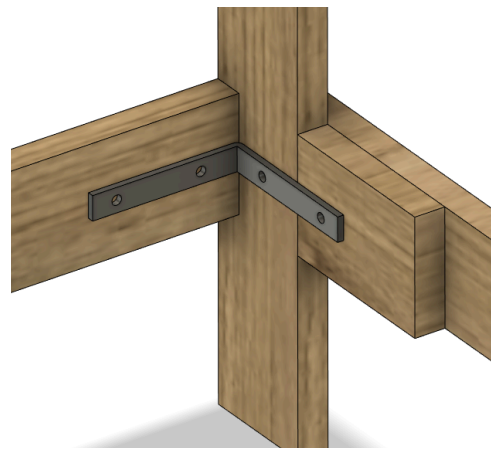
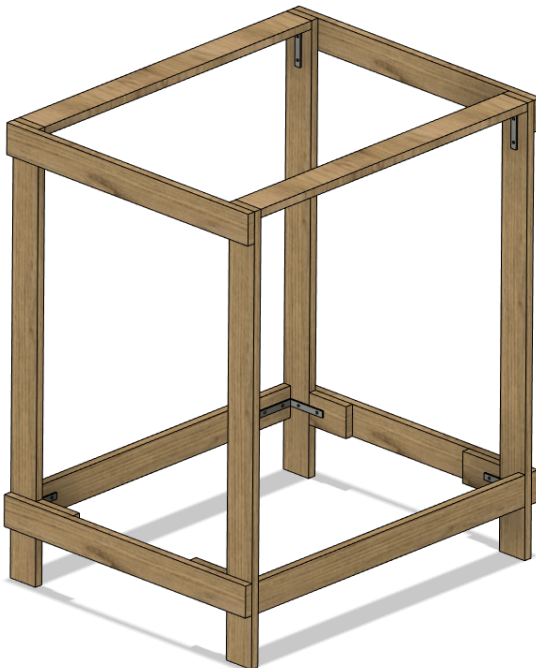
3. Screw the short 3.5" (8.89cm) pieces into the horizontal pieces as shown.



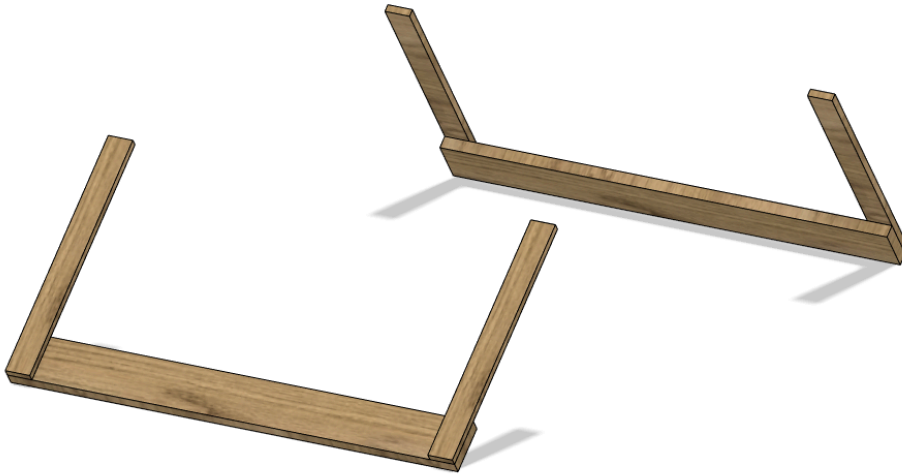
- Using four 90 degree brackets, attach the top  $26 \frac{1}{8}$ " (66.36cm) long pieces so they are flush with the top of the rest.



- Using four more 90 degree brackets to attach the lower  $26 \frac{1}{8}$ " (66.36cm) pieces also at 4" (10.16cm) from the bottom.



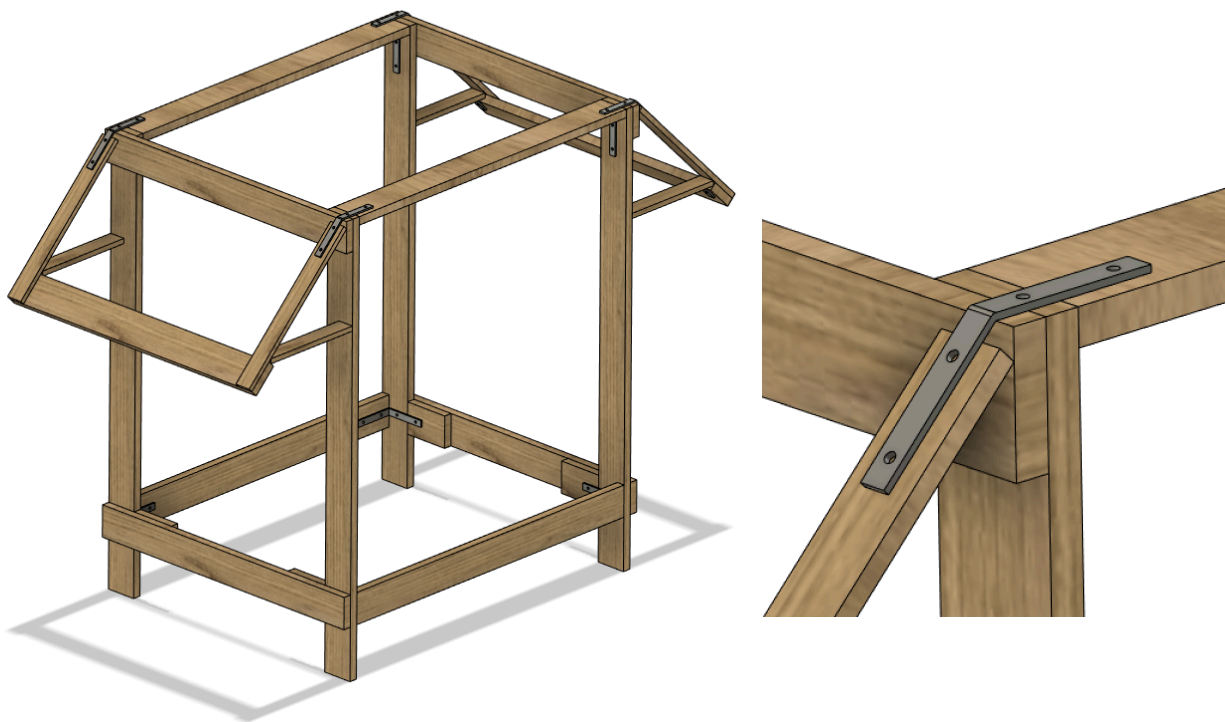
6. As a separate assembly, screw together two 13" (33.02cm) pieces to another 22 3/4" (57.79cm) piece to form a U shape. Do this twice.



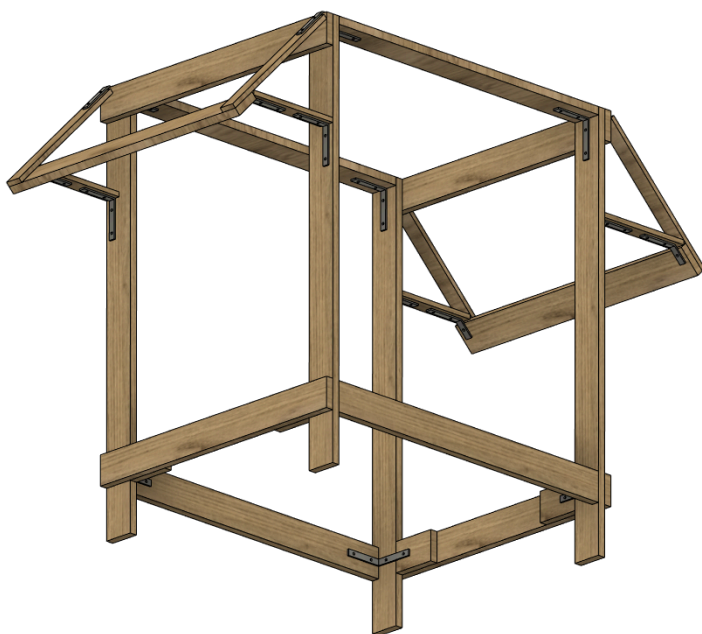
7. Use the 135 degree brackets with one leg cut short to attach the 7 15/16" (20.16cm) pieces into place. The end of those pieces rests in the corner created by the connection from Step 6. The short side of the bracket connects to the wider piece so they don't hang off the edge.



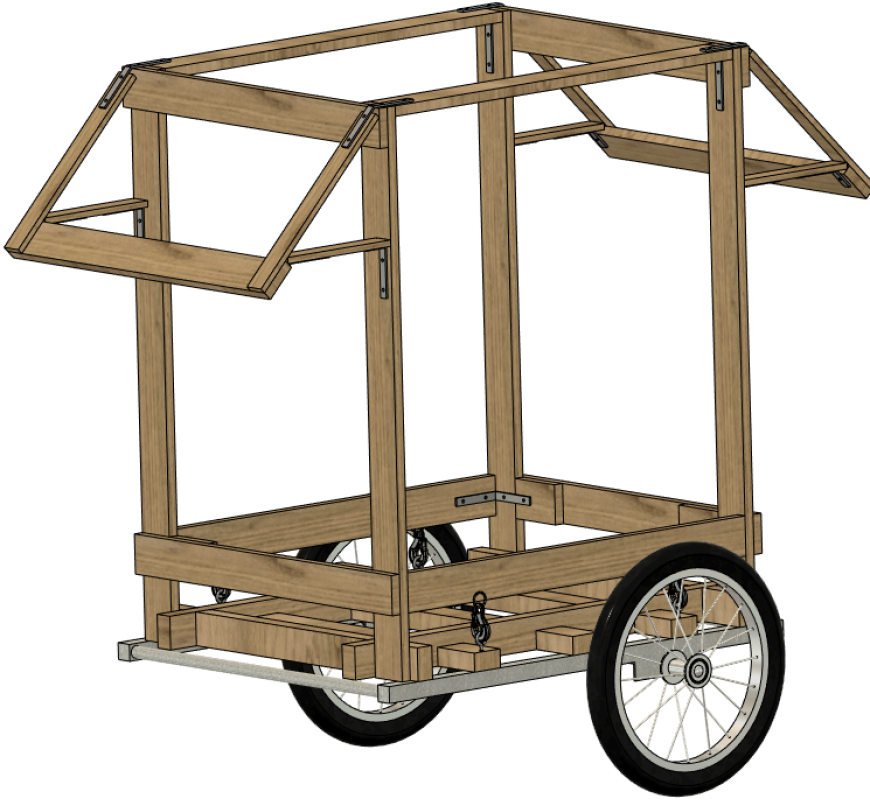
8. Use the four full sized 135 degree brackets to connect the 13" (33.02cm) pieces to the top of the rest of the shade frame.



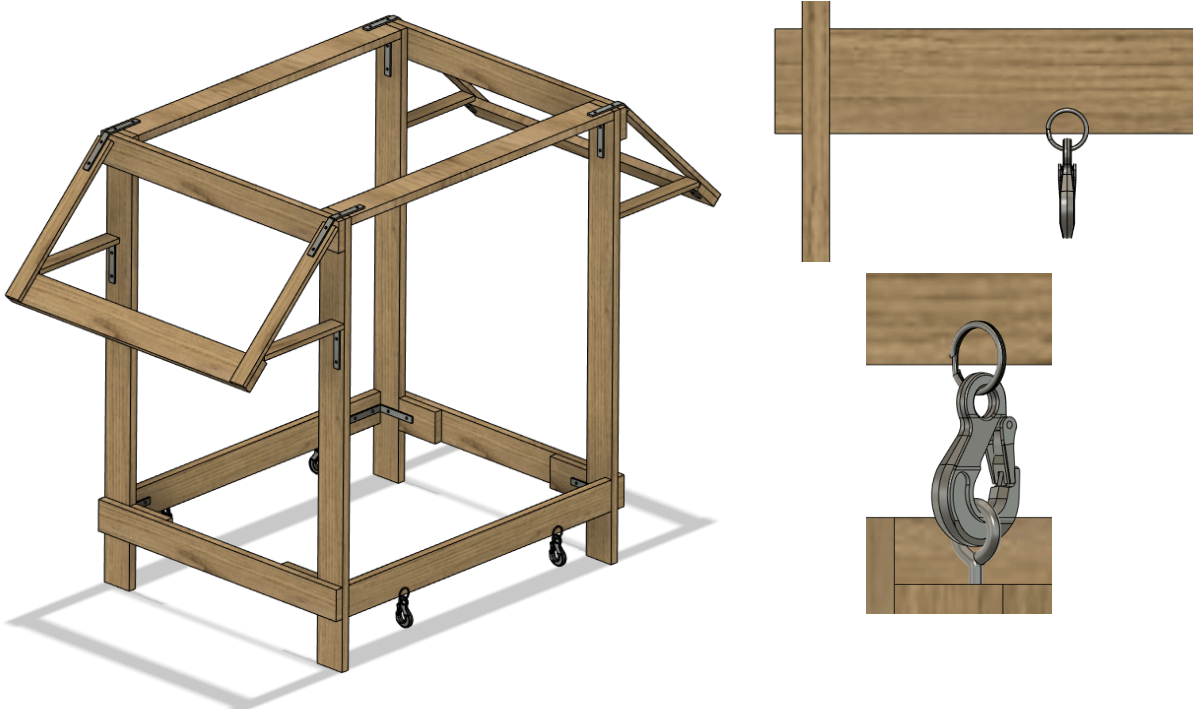
9. Use four 90 degree brackets to connect the 7 15/16" (20.16cm) pieces to the 34" (86.36cm) pieces at a height of 8 1/4" (20.91cm) as measured from the top of the assembly to the bottom of the 7 15/16" (20.16cm) bars.



10. Test the fit of the frame over the trailer. The vertical pieces should rest on the corners of the metal trailer frame, next to the wooden beams.

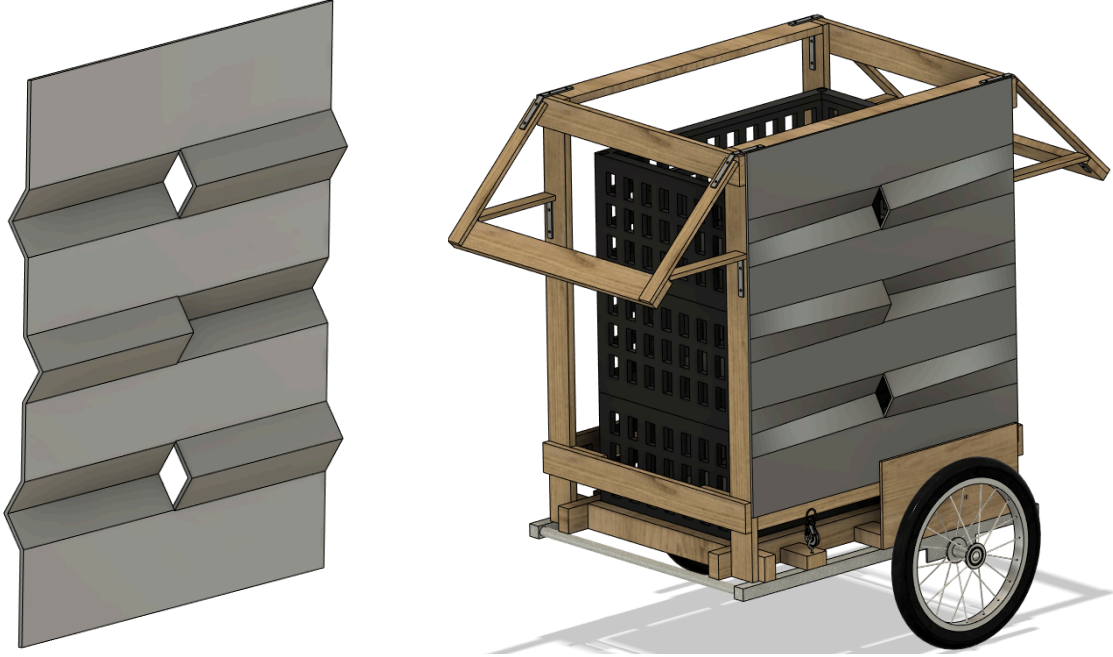


11. Attach hooks to the bottom sides of the shade frame to line up with the eye hooks in the trailer frame. This should be  $5 \frac{7}{16}$ " (13.81cm) measured from the inner plane of the 34" (86.36cm) pieces to the center of the ring holding the hook.

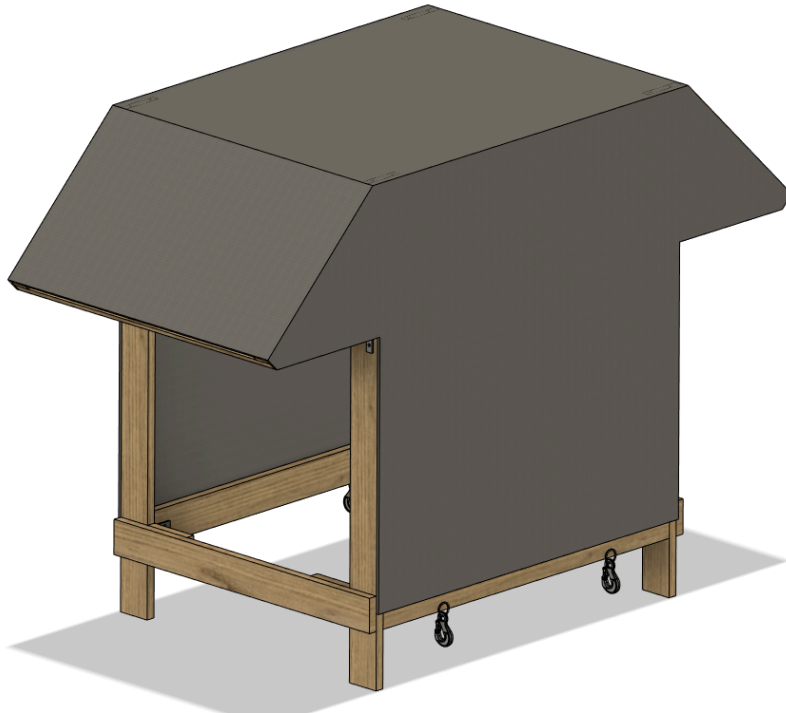




12. Cut the shade fabric to fit the sides, top, and awnings (dimensions shown in Shade Fabric Drawing). These can be separate pieces or combined into one piece. We cut 3 vertical slits into the center of each of the side pieces and creased the fabric in alternating directions to create holes for increased airflow.



13. Staple all the fabric pieces to the edges of the wood to hold them in place. Keep the front and back open to allow air flow around the crates - this will make the cooling more efficient.



## Jute Sack

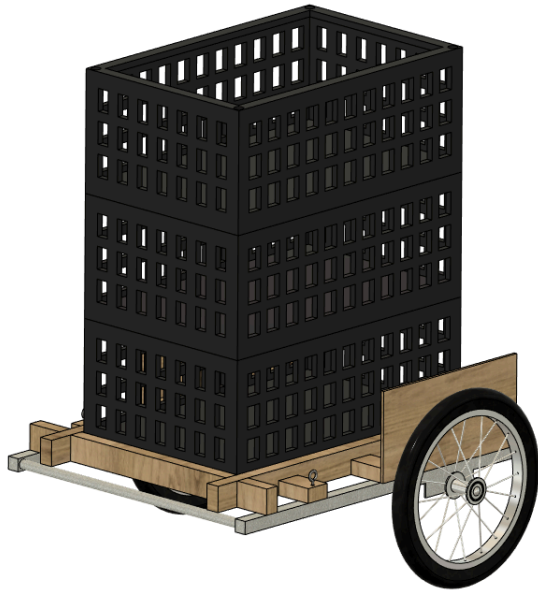
We used smaller jute sack bags and sewed them together to create a larger bag that can fit over all three crates when stacked.



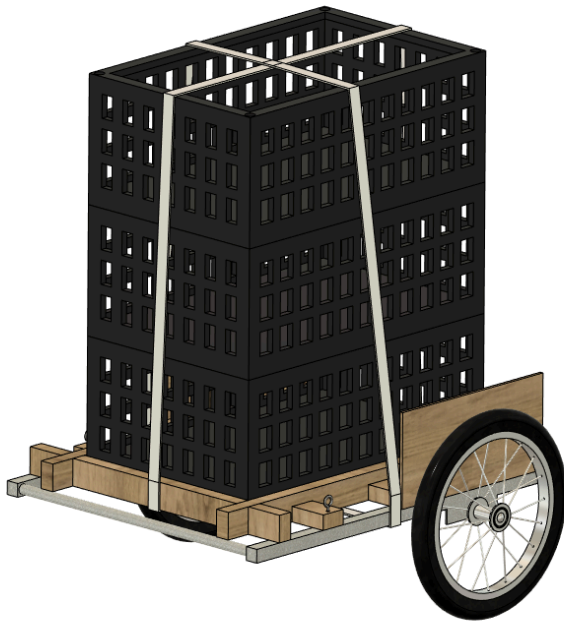


## How to Use

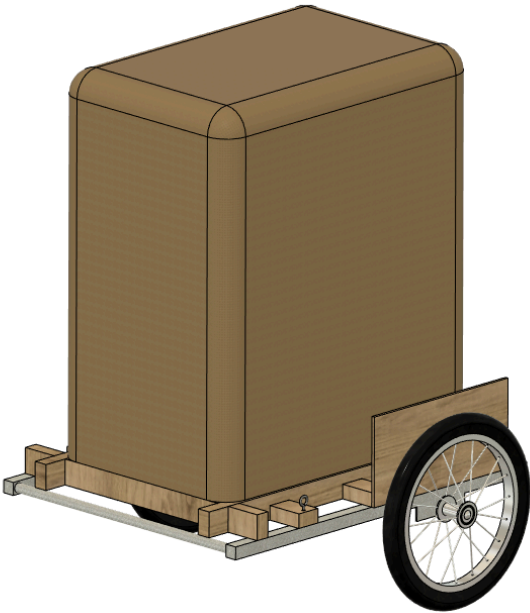
1. Fill the crates with produce. Make sure they are not overfilled such that they can still stack on each other.
2. Soak the jute sack in a bucket of water and then wring it out so that it is damp all over but not dripping a lot.
3. Stack the three crates on the trailer.



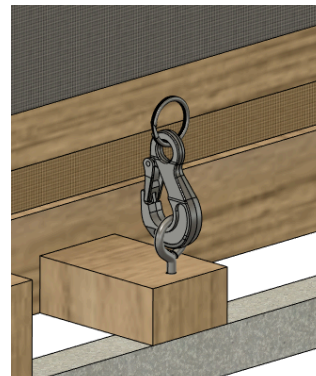
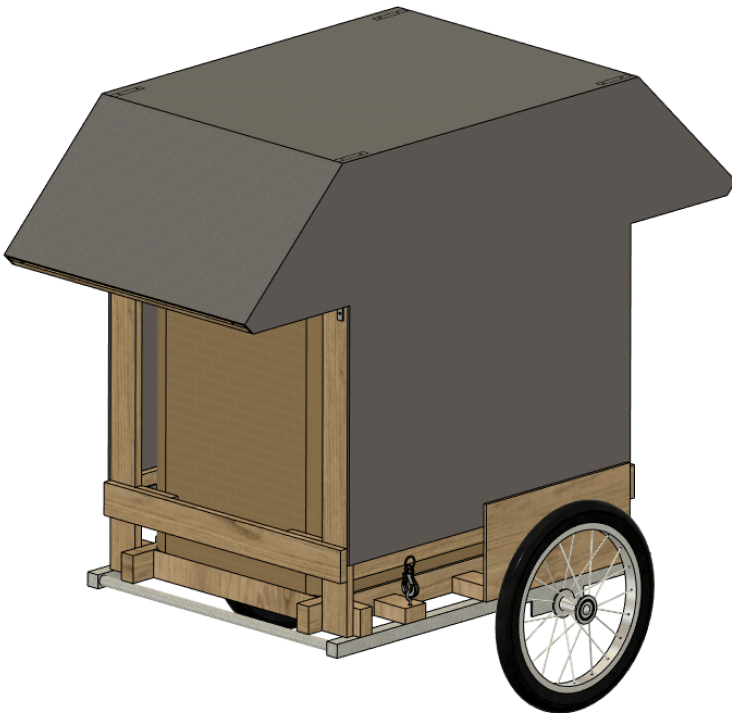
4. Tie the crate stack to the trailer with the straps - one in each direction.



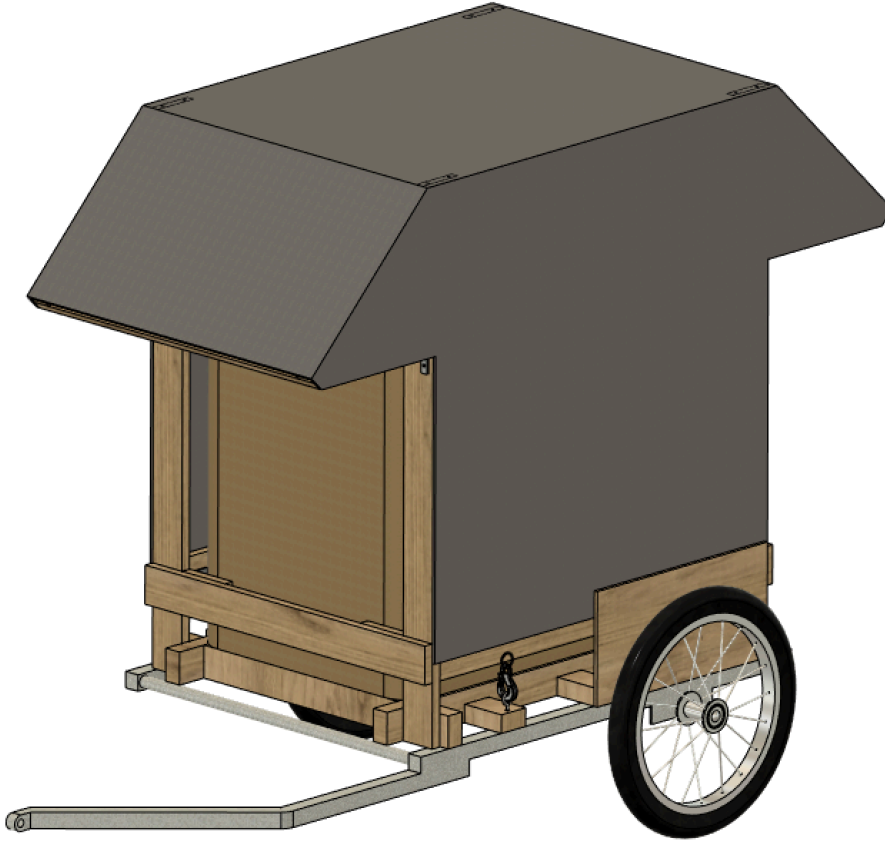
5. Put the wet jute sack over the crates. Note that it goes over the straps but the straps are not depicted here. The jute sack should remain inside the wheel protectors so nothing gets caught in the wheels.



6. Place the shade frame over the crates and attach the hooks to the eye hooks on the trailer.



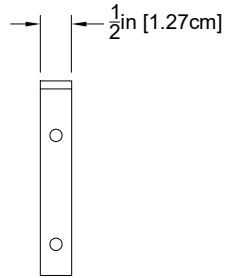
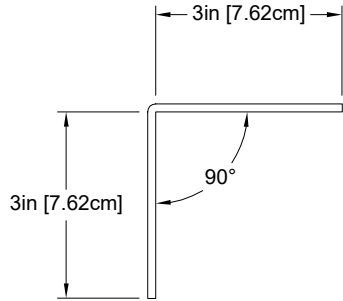
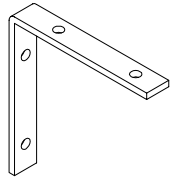
7. Attach the trailer to the bike. Note that the arm extending from the trailer was a foldable component on the trailer we used and was not depicted on any previous pictures in this document. This is where it attaches to the bike back wheel axle.



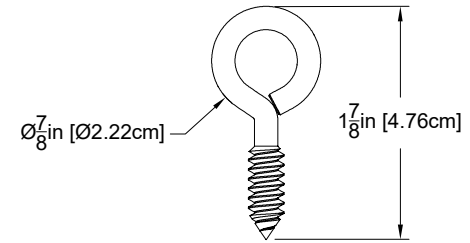
# Materials List

Component	Name	Material	Quantity	Dimensions (inches)			Dimensions (cm)			Estimated Cost	Notes	
Trailer Frame	Trailer base frame*	Metal (and rubber tires)	1	30.5 long	24 wide	15 diameter of wheels	77.47	60.96	38.1	\$115.00	It is worth buying a base trailer pre-built because of the relatively robust <a href="#">bike connection mechanism</a> , though a trailer could be created from scratch and just incorporate this part, especially at scale. ( <a href="#">example</a> )	
	Wood sheets	Wood	2	14	7	0.125	35.56	17.78	0.32	\$1.00		
	Wood screws	Metal	~20	2 long			5.08			\$4.00		
	Eye Hooks	Metal	4	~2 long	~1 diameter		5.08	2.54		\$0.50		
	Wood beams: 2" x 1.125"	Wood	5	24	2	1.125	60.96	5.08	2.86			
	Wood beams: 2" x 1.125"	Wood	2	30	2	1.125	76.20	5.08	2.86			
	Wood beams: 2.375" x 0.625"	Wood	4	34	2.375	0.625	86.36	6.03	1.59			
Shade Frame	Wood beams: 2.375" x 0.625"	Wood	4	26.125	2.375	0.625	66.36	6.03	1.59	\$20.00		
	Wood beams: 2.375" x 0.625"	Wood	6	22.75	2.375	0.625	57.79	6.03	1.59			
	Wood beams: 2.375" x 0.625"	Wood	4	3.5	2.375	0.625	8.89	6.03	1.59			
	Wood beams: 1.25" x 0.375"	Wood	4	13	2.375	0.625	33.02	6.03	1.59			
	Wood beams: 1.25" x 0.375"	Wood	4	7.9375	2.375	0.625	20.16	6.03	1.59			
	90 deg Brackets	Metal	12	3	3	0.5	7.62	7.62	1.27			\$11.00
	135 deg Brackets	Metal	4	3	3	0.5	7.62	7.62	1.27			
	135 deg Brackets - 1 leg cut in half	Metal	4	3	1.5	0.5	7.62	3.81	1.27			
	Snap hooks with key rings	Metal	4	~1.5 long hook	1 diameter of ring		3.81	2.54		\$0.08		<a href="#">example</a>
	Wood screws	Metal	~50	1 long			2.54			\$10.00		
	Shade Fabric: Top + Awning	HDPE Fabric	1	56 long	24 wide		142.24	60.96		\$25.00		order 6 ft. wide "shade fabric" made of High Density Polyethylene ( <a href="#">example</a> ), OR use reused/available materials (jutesack, used bedsheets, etc) that allows air to pass through
	Shade Fabric: Sides	HDPE Fabric	2	29 tall	27.5 wide		73.66	69.85				
	Shade Fabric: Awning Sides	HDPE Fabric	2	10	10	(cut diagonally into 4 right triangles)	25.4	25.4				
	Staples	Metal	~50	0.5 long	0.25 deep		1.27	0.635		\$1.00		
Final Assembly	Stackable Plastic Vented Crates	Plastic	3	23.5	15.5	9.5	59.69	39.37	24.13	\$19.50	search for 24" x 16" vented crate ( <a href="#">example</a> ), or use available crate and adapt trailer size to fit	
	Jute Sack	Jute Fabric	1	27.5	29	33	69.85	73.66	83.82	\$0.00	Can use Hessian sacks or whatever is easily available	
	Ratchet Tie Downs / Straps	Nylon	2	120 long	1 wide		304.8	2.54		\$4.00		
										\$211.08	Total cost if you bought the materials above, including the trailer. Cost could be reduced by about 20% if parts are purchased at scale and more if the trailer is built from scratch	
*Build own trailer base frame	Side beams (hollow steel bars)	Steel	2	30	1	1	76.2	2.54	2.54	\$15.70		
	Front/Back beams (hollow steel bars)	Steel	2	24	1	1	60.96	2.54	2.54			
	Extension to bike (hollow steel bars)	Steel	1	3	1	1	7.62	2.54	2.54			
	Bike to trailer coupler	Steel	1							\$14.27		<a href="#">example</a>
										\$126.05	Total cost if you made the trailer frame base using steel bars instead of buying a pre-built trailer	

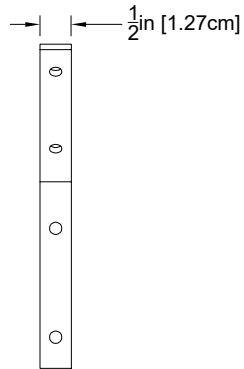
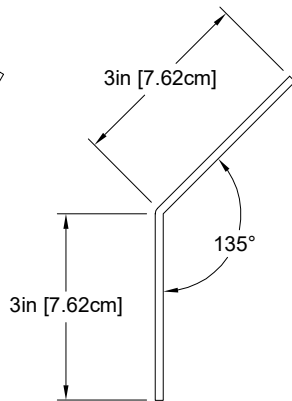
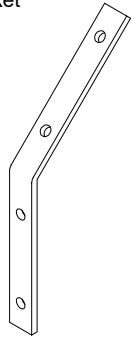
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Quantity: 12



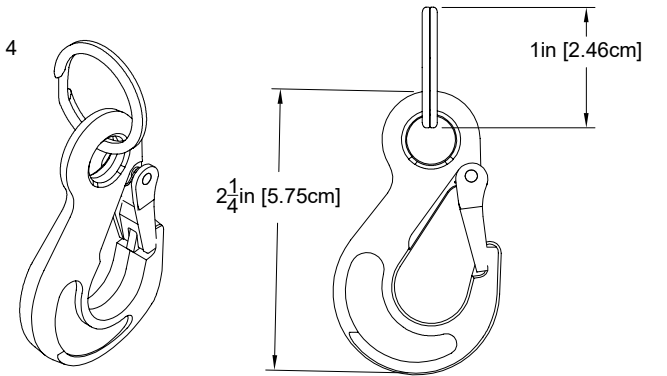
Eye Hooks  
Quantity: 4



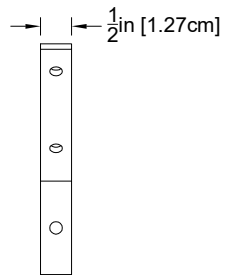
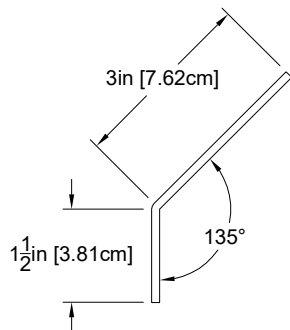
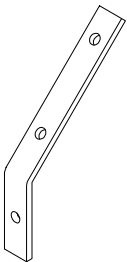
135 deg Bracket  
Quantity: 4



Hooks  
Quantity: 4



135 deg Half Bracket  
Quantity: 4



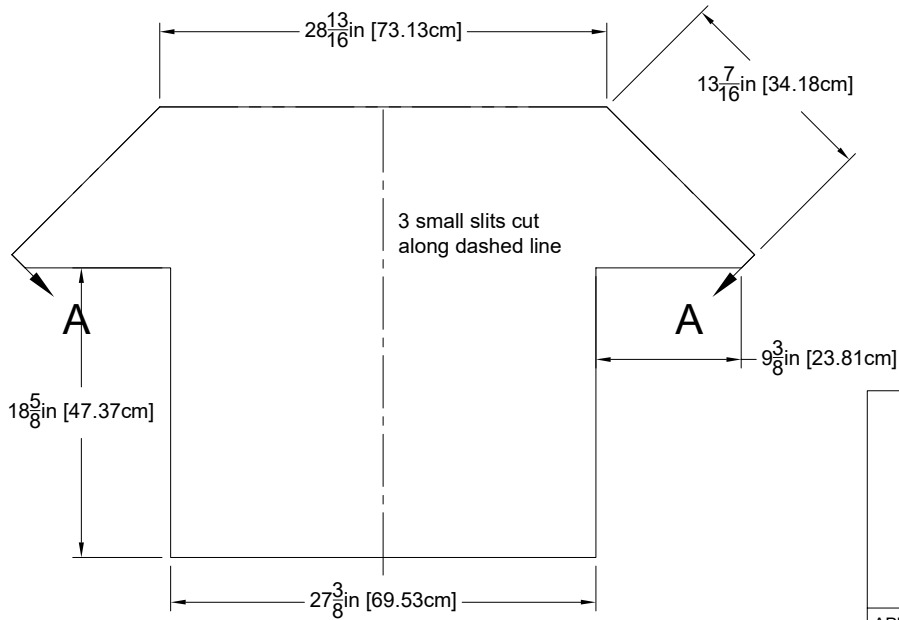
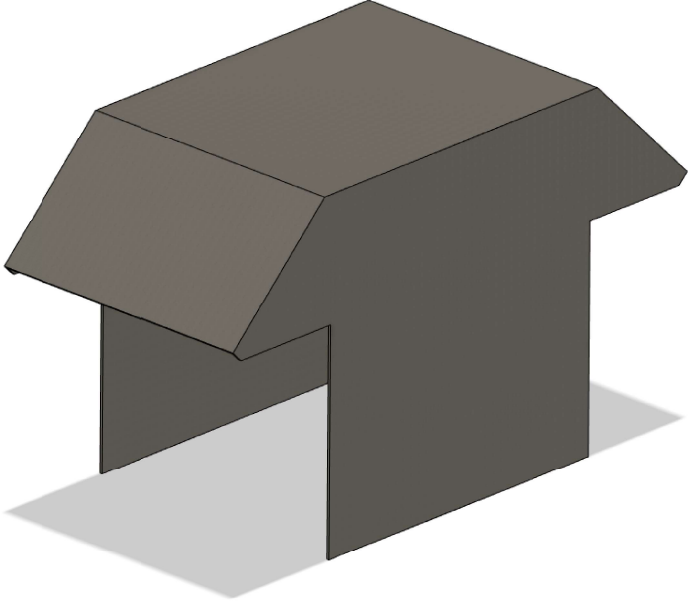
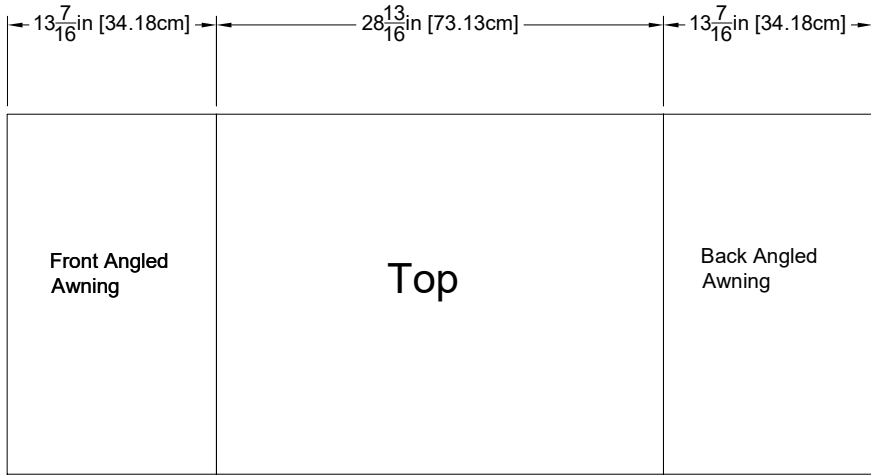
PROJECT

**D-Lab Design ~ 2023**

TITLE

**Bike Cooling Trailer  
Hardware**

APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B			
DRAWN D H	5/9/23	SCALE 1:2	WEIGHT	SHEET 1/1



		PROJECT		
		<b>D-Lab Design ~ 2023</b>		
		TITLE		
		<b>Bike Cooling Trailer Shade Fabric</b>		
APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B			
DRAWN	D H	5/16/23	SCALE 1:8	WEIGHT
				SHEET 1/1

Blue  
Quantity: 4  
 $26\frac{1}{8}'' \times 2\frac{3}{8}'' \times \frac{5}{8}''$   
66.36cm x 5.78cm x 1.59cm

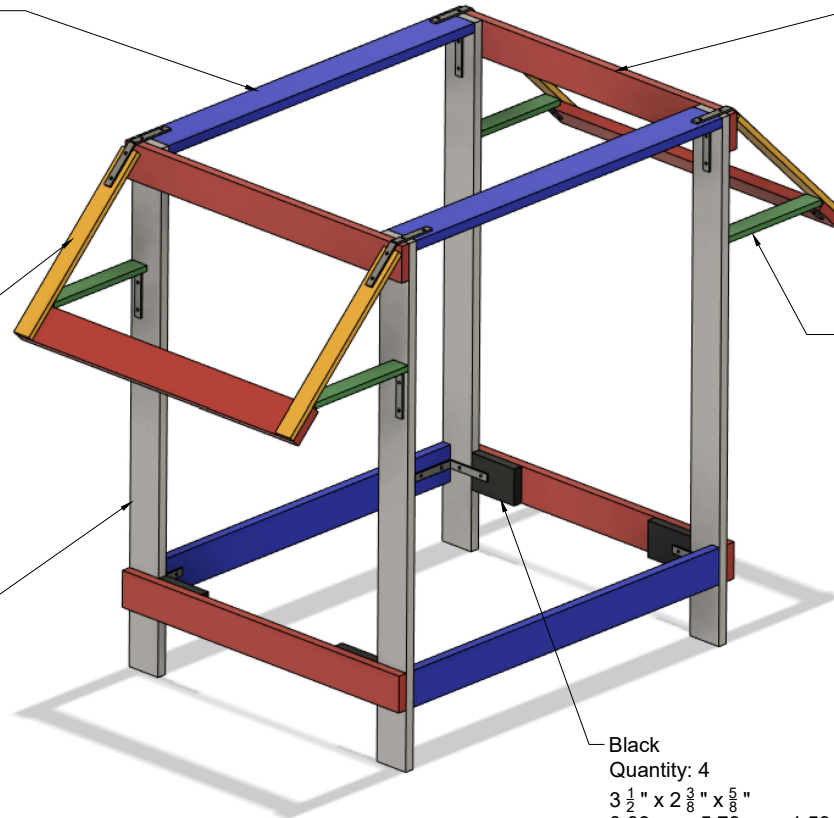
Red  
Quantity: 6  
 $22\frac{3}{4}'' \times 2\frac{3}{8}'' \times \frac{5}{8}''$   
57.79cm x 5.78cm x 1.59cm

Yellow  
Quantity: 4  
 $13'' \times 1\frac{1}{4}'' \times \frac{3}{8}''$   
33.02cm x 3.18cm x 0.95cm

Green  
Quantity: 4  
 $7\frac{15}{16}'' \times 1\frac{1}{4}'' \times \frac{3}{8}''$   
20.16cm x 3.18cm x 0.95cm

Gray  
Quantity: 4  
 $34'' \times 2\frac{3}{8}'' \times \frac{5}{8}''$   
86.36cm x 5.78cm x 1.59cm

Black  
Quantity: 4  
 $3\frac{1}{2}'' \times 2\frac{3}{8}'' \times \frac{5}{8}''$   
8.89cm x 5.78cm x 1.59cm

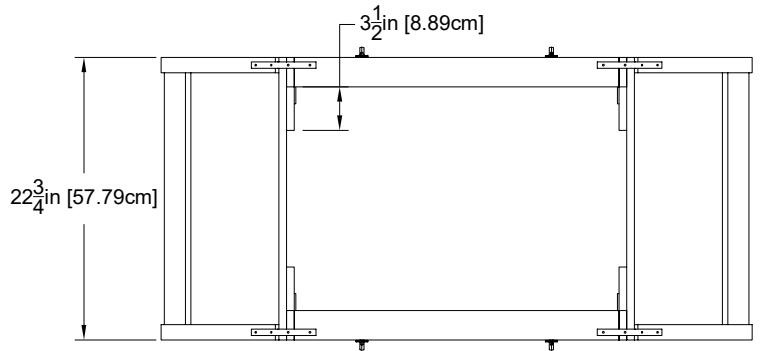
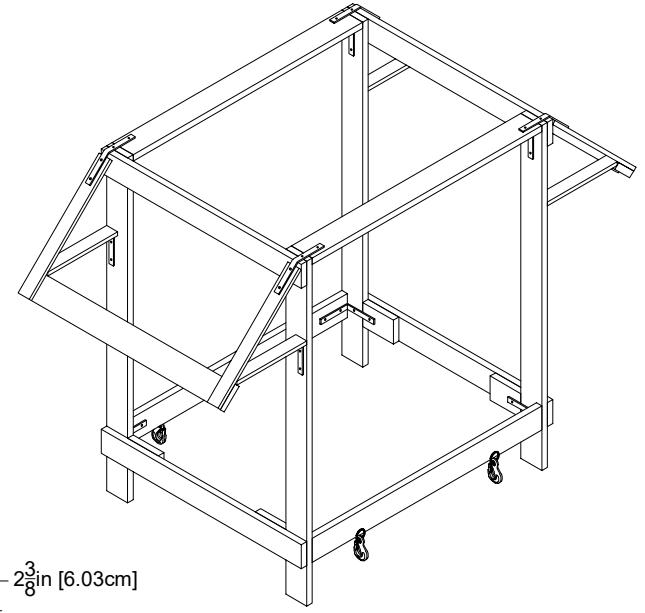
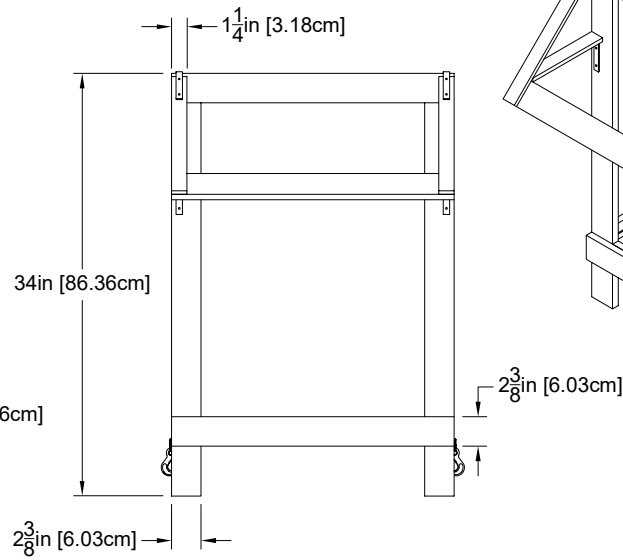
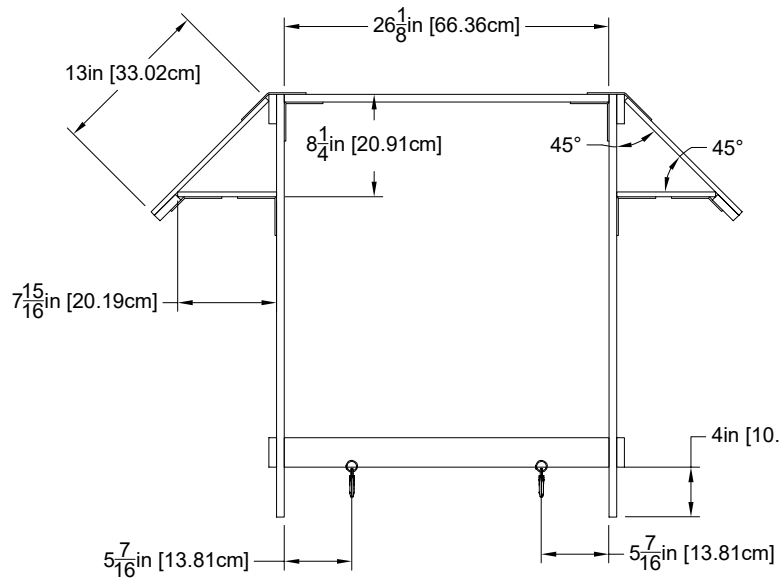


PROJECT  
**D-Lab Design ~ 2023**

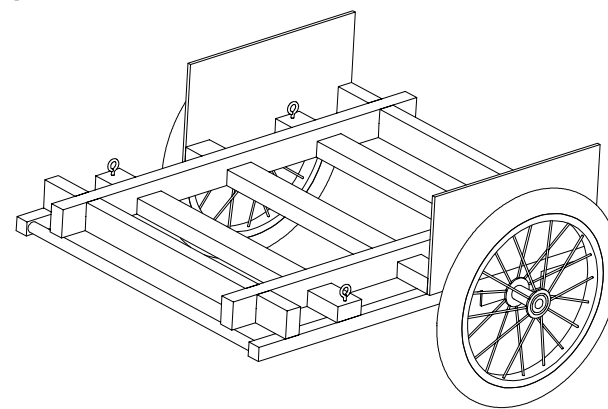
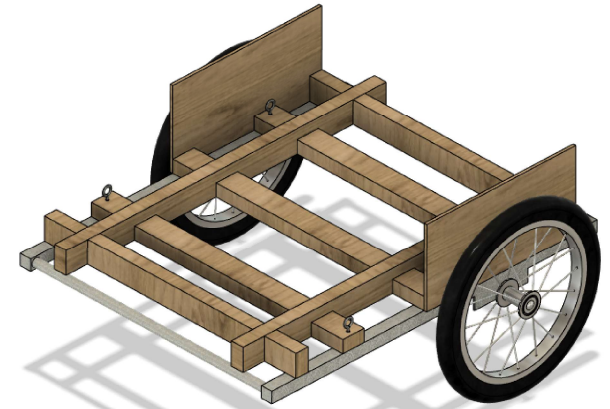
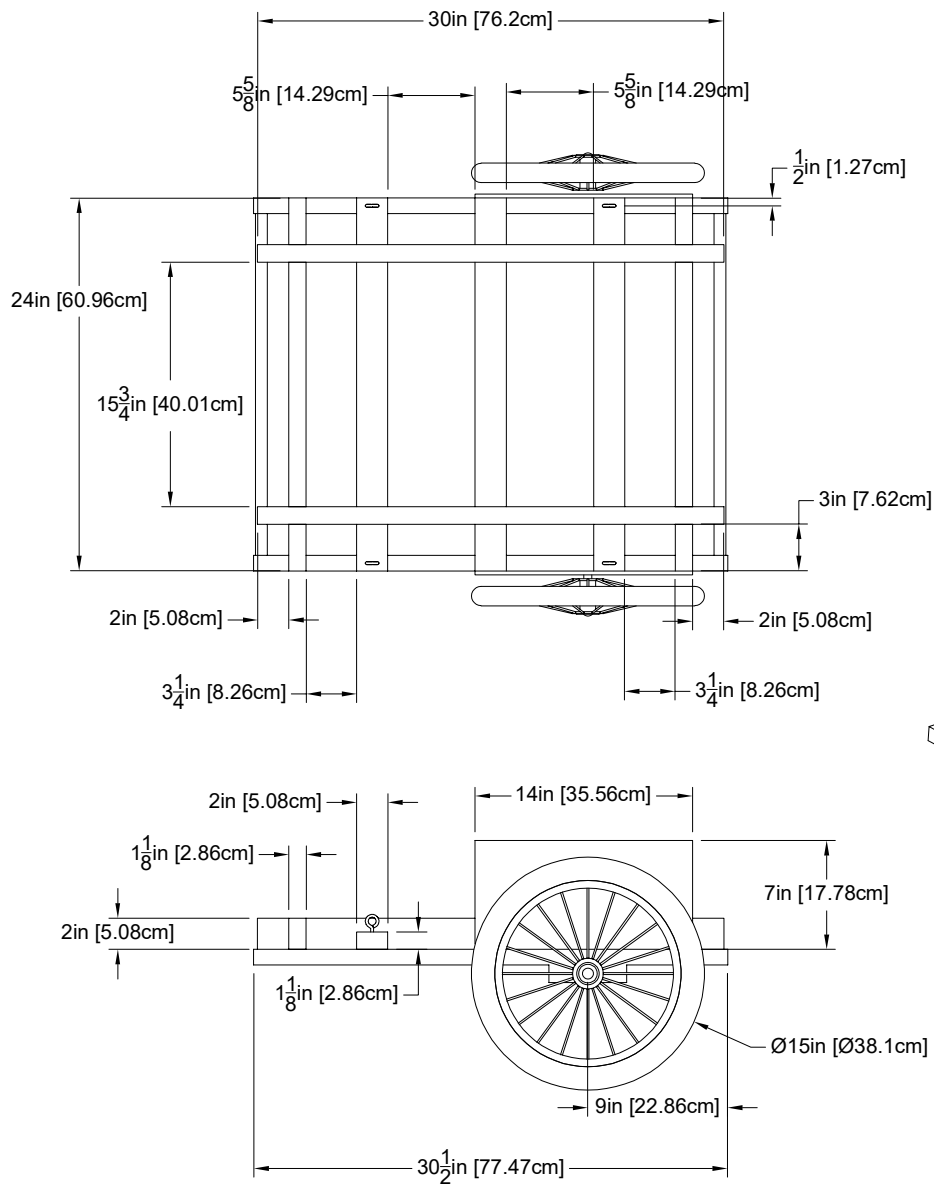
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**Bike Cooling Trailer  
Shade Frame Parts**

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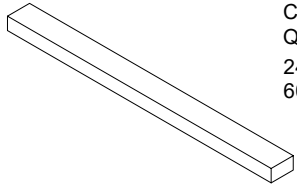




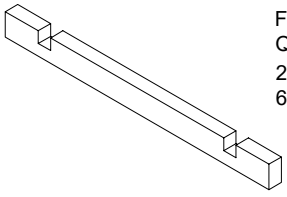
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TITLE				
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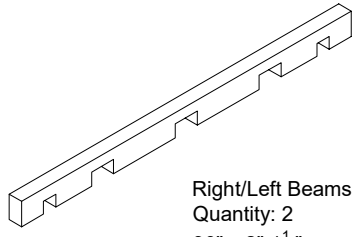
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CHECKED	B			
DRAWN D H	5/5/23	SCALE 1:8	WEIGHT	SHEET 1/1



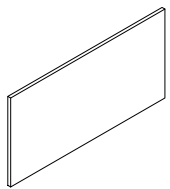
**Cross Beams**  
 Quantity: 3  
 24" x 2" x 1 1/8"  
 60.96cm x 5.08cm x 2.86cm



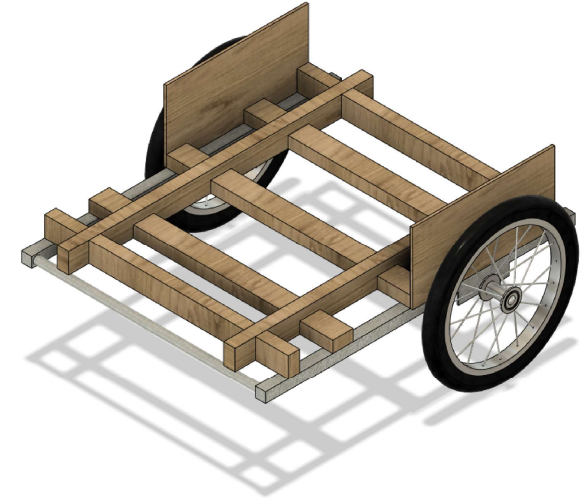
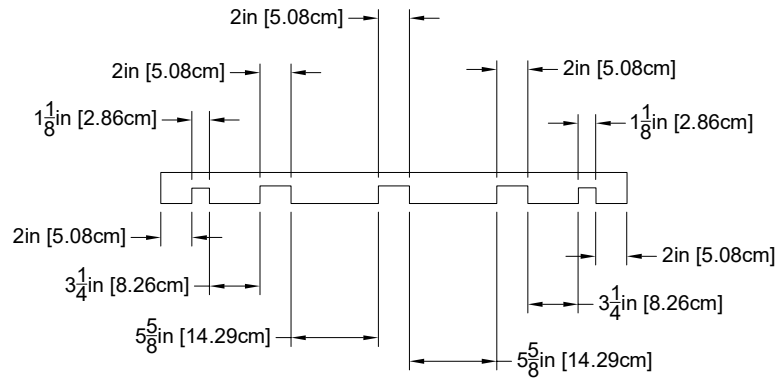
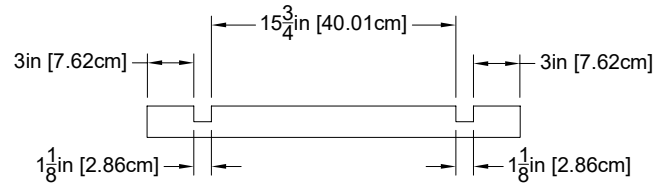
**Front/Back Beams**  
 Quantity: 2  
 24" x 2" x 1 1/8"  
 60.96cm x 5.08cm x 2.86cm



**Right/Left Beams**  
 Quantity: 2  
 30" x 2" x 1 1/8"  
 76.20cm x 5.08cm x 2.86cm



**Wheel Protectors**  
 Quantity: 2  
 14" x 7" x 1/8"  
 35.56cm x 17.78cm x 0.32cm



		PROJECT		
		<b>D-Lab Design ~ 2023</b>		
		TITLE		
		<b>Bike Cooling Trailer Trailer Frame Parts</b>		
APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B			
DRAWN	DH	5/5/23	SCALE 1:8	WEIGHT
				SHEET 1/1