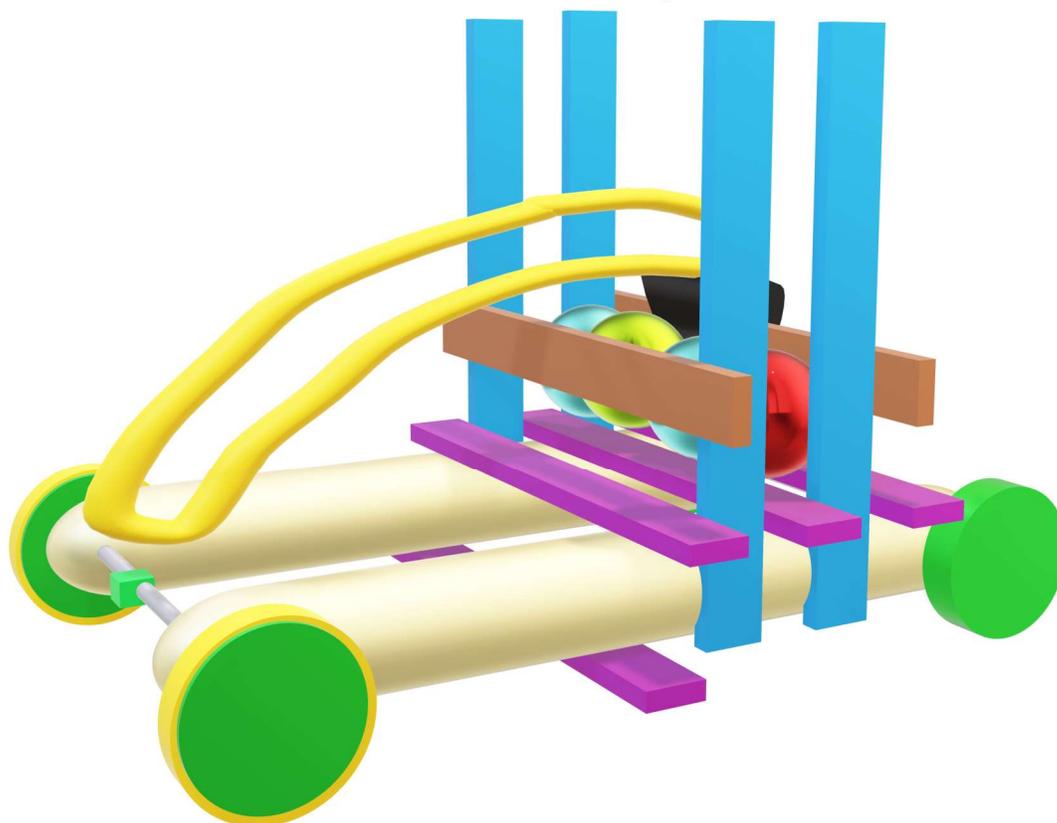


Junk Draw Robot Marble Transporter



V1.1 6-27-22

Duration: 2 to 4 hours

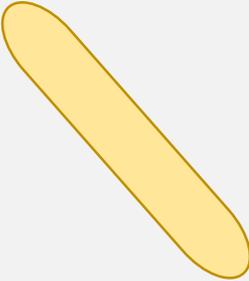
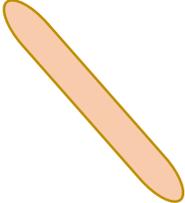
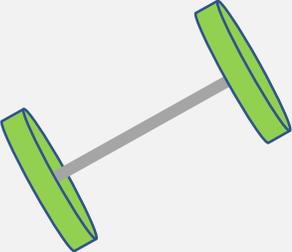
Age range: 10 years and up

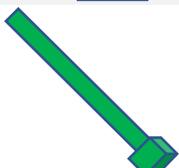
Power Source: Rubber band (kinetic energy)

Developed by: Tony Foster for Kansas 4-H STEM

This guide provides instructions to construct a marble transporter from common items found in the home. The purpose of the marble transporter is to move marbles from one place to another. As you work through this you can make modifications (make note of them) to the design to improve the transporter.

What You'll Need:

Qty.	Item	Visual
2	Large craft sticks https://www.amazon.com/gp/product/B07G84W78G/	
10 or 14	Popsicle sticks https://www.amazon.com/gp/product/B08SJF35Y1/	
8	[Optional] Sawtooth craft sticks (helps with alignment, if not used you will need 13 popsicle sticks) https://www.amazon.com/gp/product/B087RMMYV1/	
~10	Marbles https://www.amazon.com/gp/product/B09D3CD343/	
2	Wheel and axel sets https://www.amazon.com/gp/product/B09335BTQ2/	
1 or 2	Rubber bands (long)	

Qty	item	Visual
1 or 2	Wider rubber bands (width of wheel thickness)	
1	Small binder clip https://www.amazon.com/gp/product/B09VGXMSFW/	
1	Small zip tie	
1	Tube of super glue or similar (& nail polish remover to release stuck fingers)	

Other tools needed:

Scissors, drill, 1/8" drill bit, masking tape, wax paper, scrap block of wood, marker

Preparation

This project can get messy, it is highly recommended that you put down a layer of news paper or similar before starting to catch any drips that may occur. Wax paper may also be desirable to keep parts from sticking to the work surface.

You will want at least a 2-foot square working area to assemble your robot. When working with groups it is best to have builders on one side of the table and have the other side open for assistants to work with the builders as they go.

The use of sawtooth craft sticks is optional. They have notches in them that provide a consistent alignment of parts and make assembly much easier. However, they are not required. If you choose not to use them 13 popsicle sticks instead of 9. (You may think the numbers don't make sense, 4 of the sawtooth sticks are used to create a platform for the base.)

When working with groups it is recommended to pre-complete some tasks to ensure consistency and safety for the group and prevent bottle necks. Steps 1 through 4 can be done in advance of the build and may be necessary to do for younger participants. For younger participants it may even be desirable to pre assemble the transport cage and part of the chassis depending on the patience of the youth.

UPDATE: After doing additional testing with younger youth, Super Glue may not be the best option. If the activity is split into several days, you could use white glue (Elmer's Glue) to construct the transporter. I am still testing other options for gluing things together and will update this guide when something suitable is found.

Construction

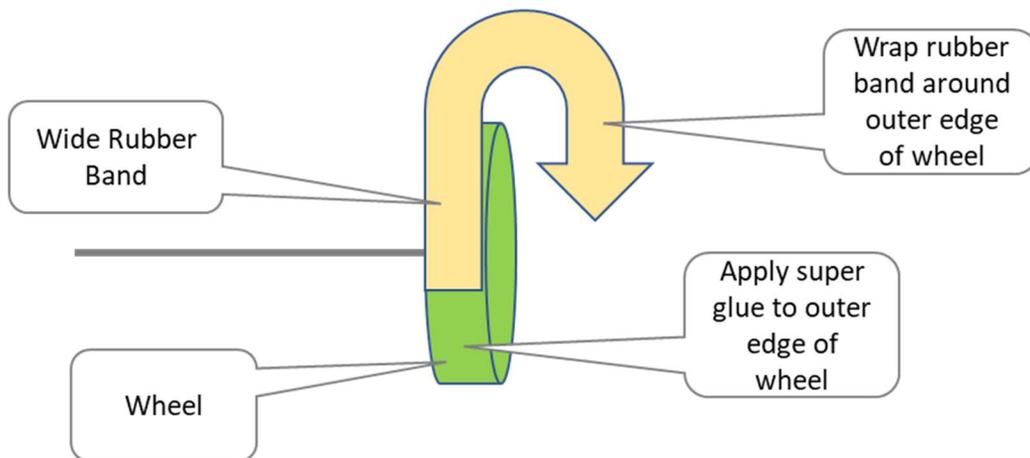
Component Preparation

The steps in this section can be done in advance for group builds and for younger builders.

Step 1. Drive wheel preparation

Supplies used in this step: 2 wheels from wheel and axel set, wider rubber band, super glue

- Take the wider rubber band and cut it so it is no longer a loop.
 - Wrap the rubber band around one of the two wheels and mark where the rubber band overlaps or meets.
 - Cut the rubber band at the mark
 - Test wrap the cut rubber band to the wheel and see if it needs trimmed, trim if needed
 - Apply super glue to the outer edge of the wheel and wrap the cut rubber band around the wheel
- NOTE: Some super glues may be to "thin" and you may wish to use plastic cement or a [vinyl, fabric, and plastic adhesive](#)*
- Once glue has been applied, if the rubber band wants to come loose from the tire while drying wrap a piece of masking tape around the tire and rubber band to hold it in place
 - Place on wax paper to dry
 - Repeat this process for the second wheel



Why we do this: We need more grip than the plastic wheels can provide. By gluing the rubber band to the wheels, we can create more grip, so our transporter doesn't spin out.

Think: Are car tires plastic? How do they create additional grip with the road?

Step 2. Drilling axel holes

Supplies used in this step: Large craft sticks, drill, 1/8" drill bit, ruler, scrap block of wood

- Measure 1/2" from either end of the large craft stick and place a mark
- On the same end, measure down from the top of the craft stick ~5/16" to the middle of the craft stick
- Mark an X where the measurements from a) and b) meet
- Repeat this the other end of the craft stick

- e) Using the drill and drill bit, drill holes at the two X's
 - a. Craft sticks are brittle, do not press hard on the drill or you may crack the craft stick
 - b. You may wish to place the stick on a scrap block of wood to drill the holes
 - c. If doing a bulk build you can stack the sticks together, clamp them, and drill holes through the stack, being sure to keep the drill square
 - d. You may wish to do "matched pairs" when making them in bulk, this is because alignment of the holes may be slightly different from the craft stick at the top to the craft stick at the bottom
 - i. You can use a non-yellow highlighter to mark holes at one end so that the highlighted holes both go on the same end
- f) Repeat for other large craft stick
- g) You should now have two large craft sticks with holes at each end.



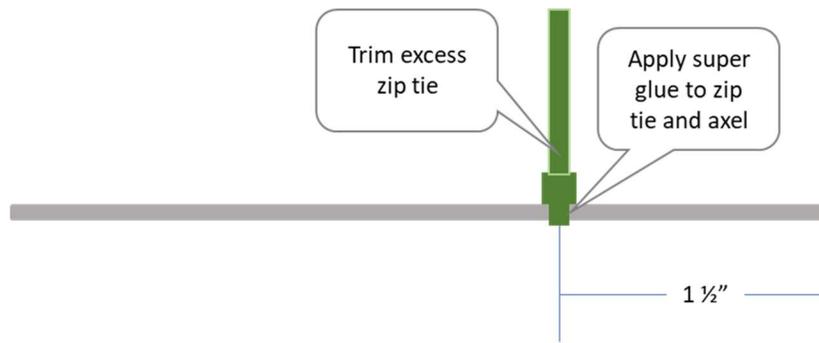
Why we do this: We need a place for our axels to pass through our transporter, so the wheels and axels don't fall off as the transporter moves. This is what is known as a fixed axel design and does not allow for steering to the right or the left.

Think: Why doesn't this design, with a fixed axel, allow the transporter to steer to the right or left?

Step 3. Preparing the drive axel

Supplies used: 1x axel from wheel and axel set, small zip tie, super glue

- a) Measure 1 1/2" from one end of the axel and mark it with a marker
- b) Fasten the small zip tie around the axel at this mark
- c) Tighten the zip tie as tight as possible
- d) Place a drop of super glue where the zip tie wraps around the axel
 - a. This keeps the zip tie from spinning
- e) Set the axel on wax paper to dry
- f) When dry ensure that the zip tie does not spin on the axel, if it does tighten zip tie and/or add more super glue
- g) When dry trim the excess end off of zip tie with scissors, you may want to file the trim as it can be pointy and sharp



Why we do this: The rubber band powering our transporter will wrap around the axle and this provides a location for the rubber band to grip as it is wound, storing potential energy in a stretched rubber band.

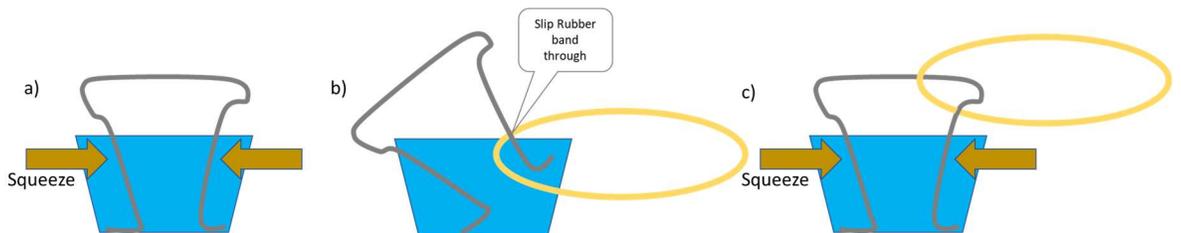
Think: Why is it important that the zip tie doesn't spin on the axle? If it weren't tight what would happen when we try to wrap a rubber band around it?

Step 4. Connecting the drive rubber band to the binder clip

This step can be difficult, or it can be easy, it is listed here as something that can be done in advance because of the potential difficulty.

Supplies used: Small binder clip, rubber band

- Take the small binder clip and squeeze one of the metal arms to release it from the clip
- Guide the rubber band through the released arm
- Squeeze the arm and reattach it to the binder clip
- The rubber band should now be attached to the binder clip



Why we do this: This creates a quick and adjustable method for attaching our power source to our transporter.

Think: Are there other ways we could attach the rubber band to the binder clip?

Major component assembly

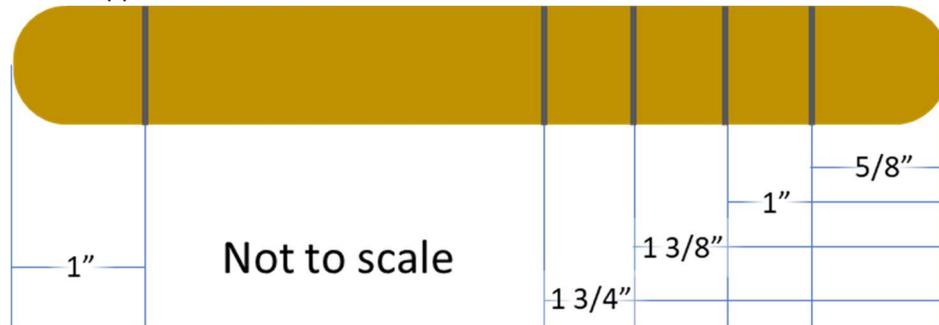
This section covers the assembly of the chassis and carrying space for the transporter. For this construction we use super glue to connect the various parts together. When working with super glue we want to use small amounts. This allows the items to bond and set faster than if we used large amounts. Once things are joined together, we can reinforce the bond with additional small amounts of super glue.

Step 5. Constructing the carrying space.

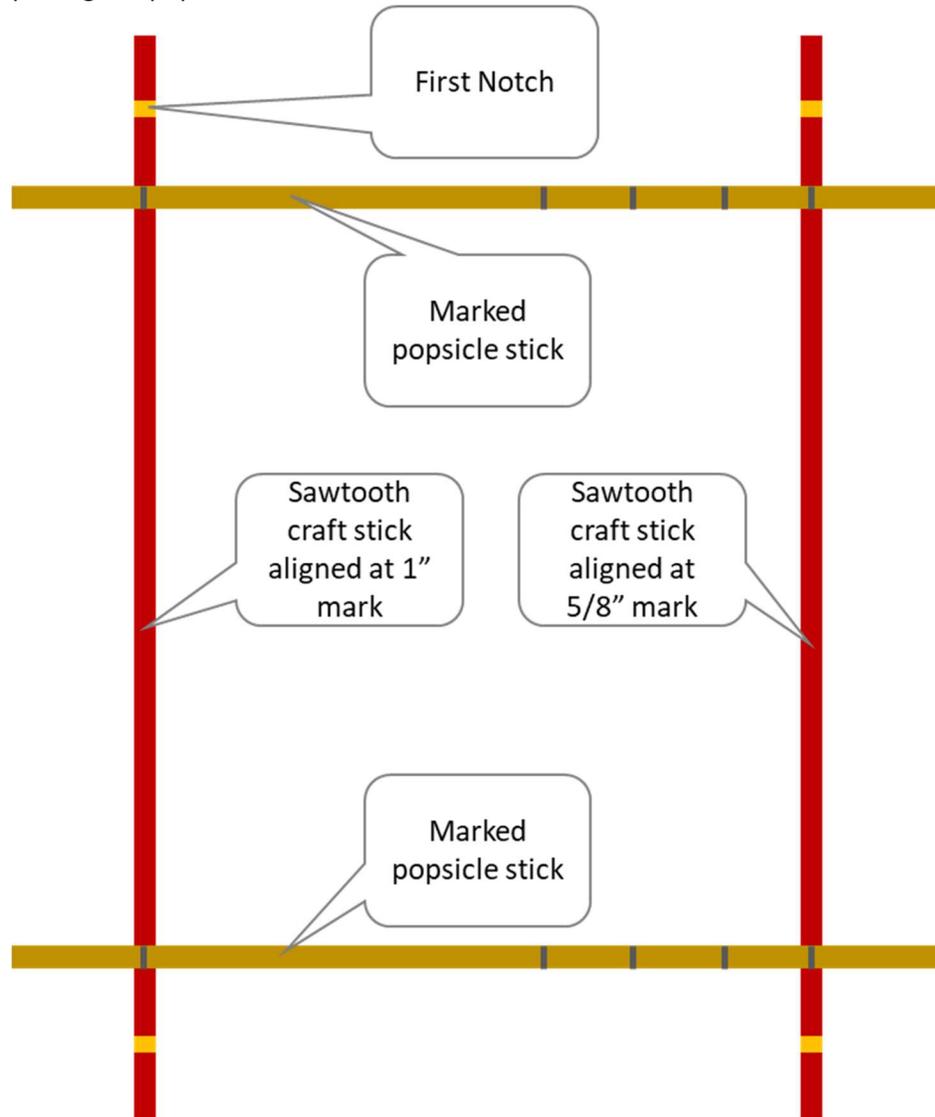
Supplies used: Popsicle sticks (4 marked, 4 unmarked), sawtooth craft sticks (2), super glue

Part 1.

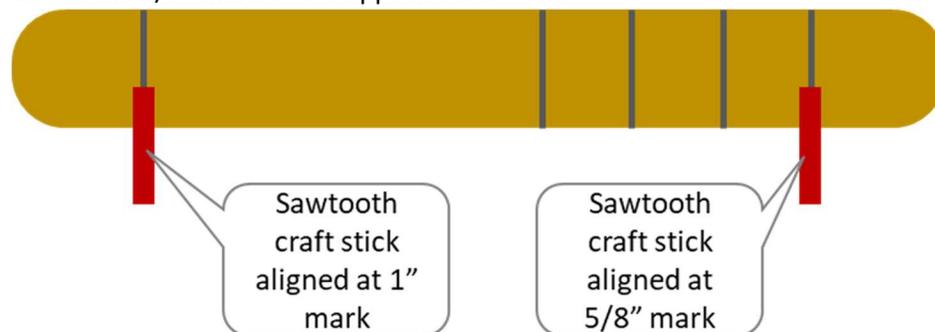
- Mark one end of 4 popsicle sticks $5/8$ " from the end
- On the same 4 popsicle sticks make a mark 1 " from the same end
- Again, on the same 4 popsicle sticks make a mark $1\ 3/8$ " from the same end
- Lastly, on the same 4 popsicle sticks make a mark at $1\ 3/4$ " from the same end
- At the opposite end make a mark 1 " from the end



- f) Using 2 marked popsicle sticks and 2 of the sawtooth craft sticks, create a rectangle by placing the popsicle sticks in the notches of the sawtooth stick second from each end



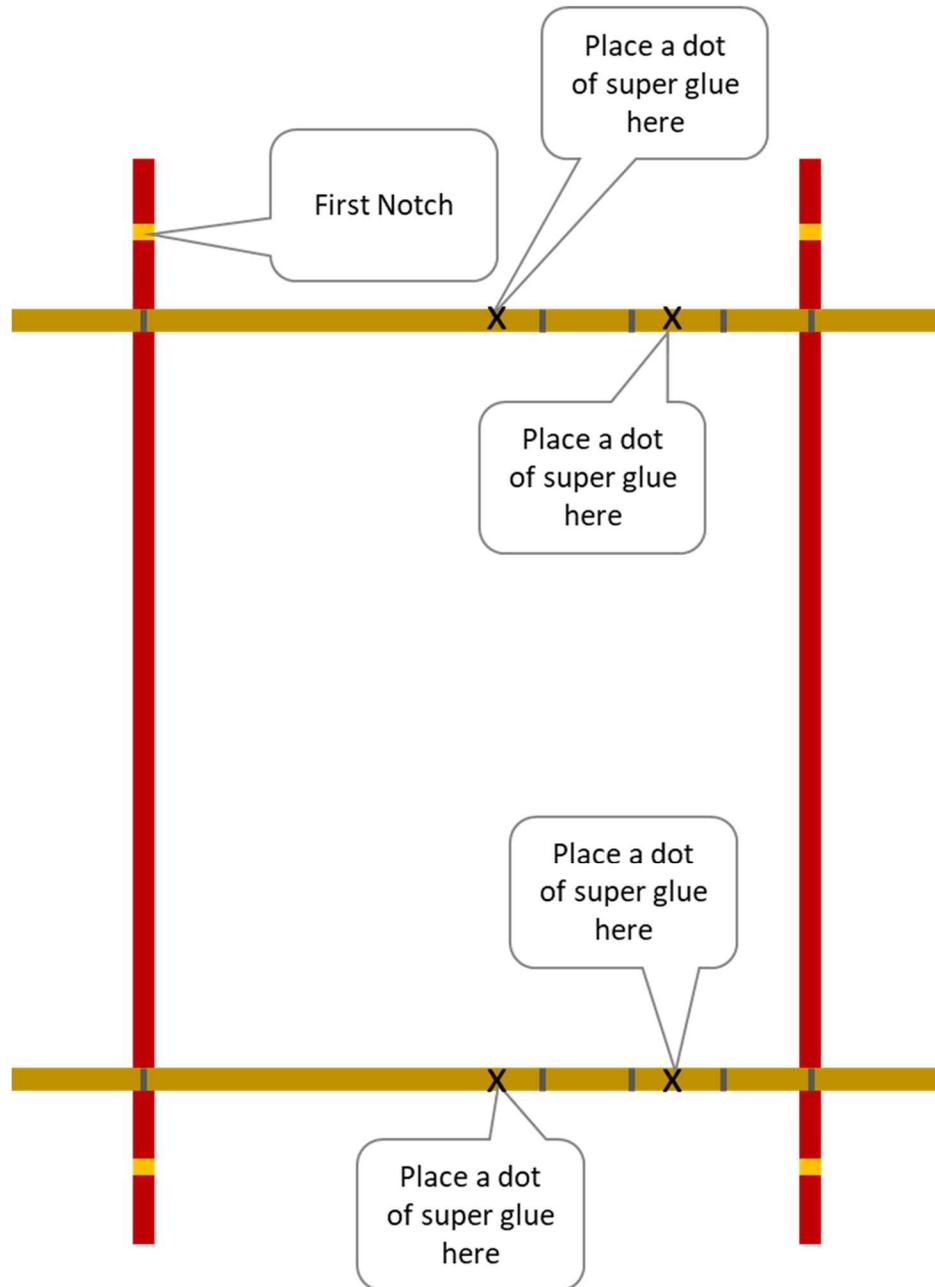
- g) Align one end with the single 1" mark at the far end of the popsicle stick and the other end at the 5/8" mark at the opposite end



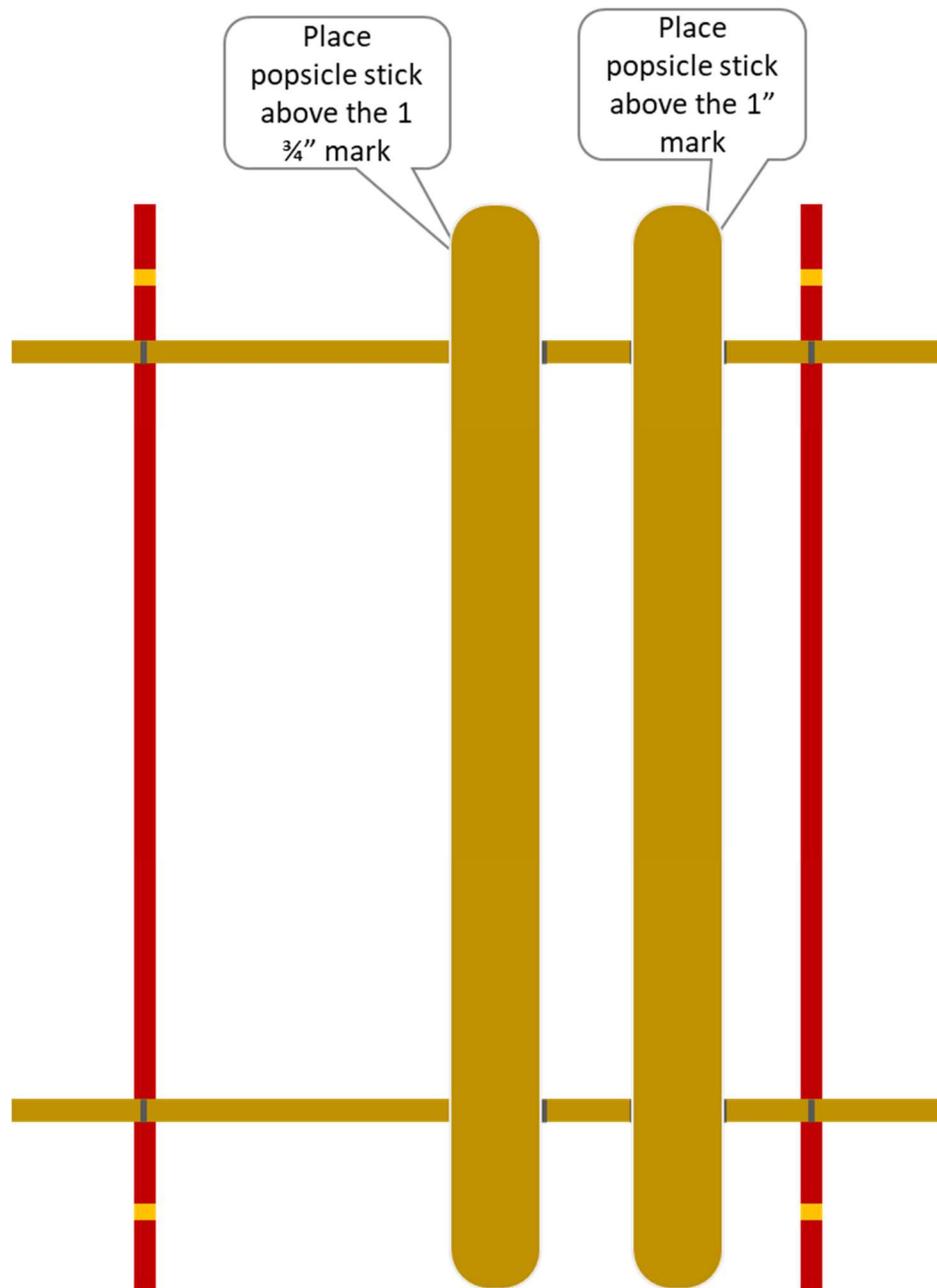
- h) Apply a dot of super glue at each joint and allow to dry on a flat surface

Part 2.

- a) While the box is drying place a dot of super glue on the 2 marked popsicle sticks of the box, above the 1" mark and above the 1 ¾" mark



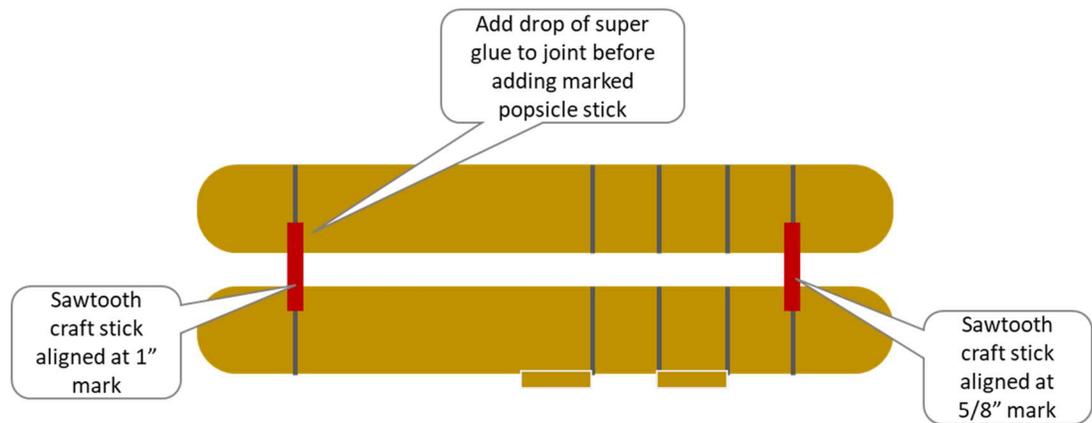
- b) Place an additional popsicle stick across the two popsicle sticks aligning it to the 1" mark
- c) Place an additional popsicle stick across the two popsicle sticks aligning it with the 1 3/4" mark



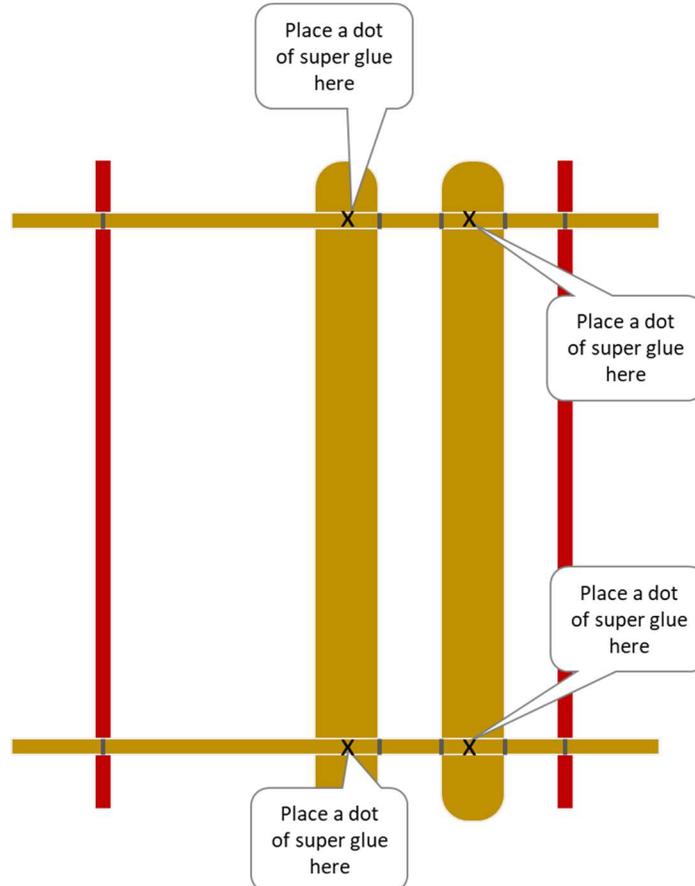
- d) Allow to dry

Part 3.

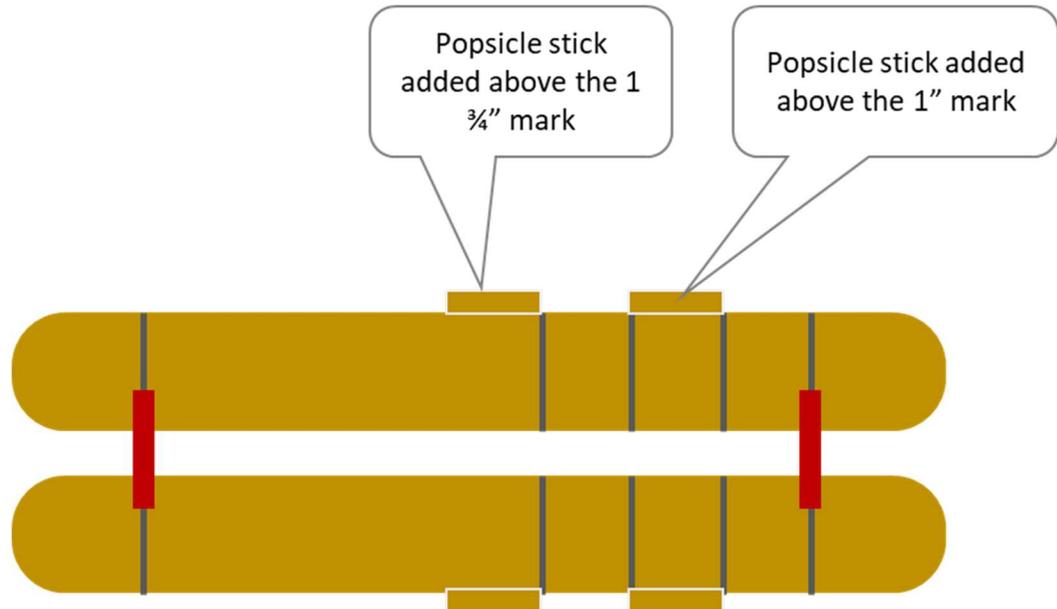
- a) Once the square created in Parts 1 & 2 is dry flip it over and apply dots of super glue to the 2 popsicle sticks added in step 2 b) & c)
- b) Place a drop of super glue in the slots of the sawtooth popsicle stick that match with the marked popsicle sticks already glued in place
- c) Insert remaining 2 marked popsicle sticks into the freshly super glued slots so that the marks line up with the other marked popsicle sticks



- d) While the newly added marked popsicle sticks dry add a dot of super glue to the marked popsicle sticks above the 1" and 1 3/4" marks



- e) Place the remaining 2 popsicle sticks on top of the super glue dots aligned above the 1" and 1 ¾" marks

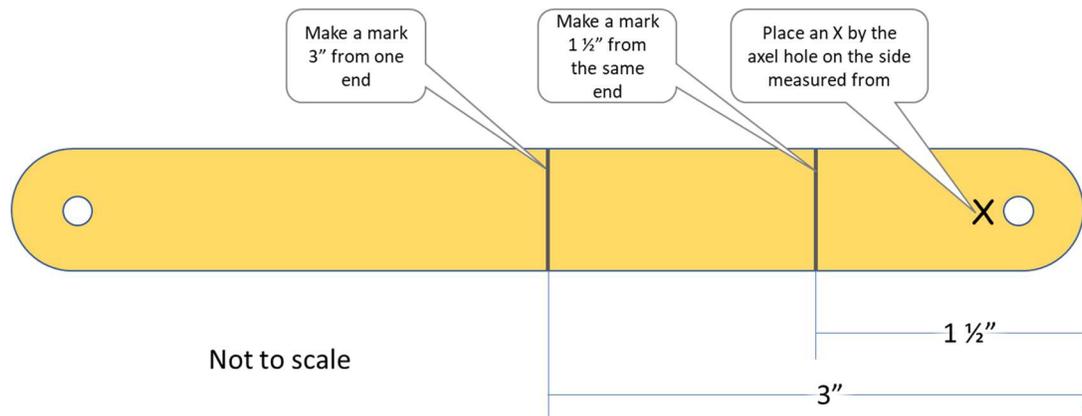


- f) You may reinforce joints once the carrying space is cured
g) Set aside to dry and move on to the next section

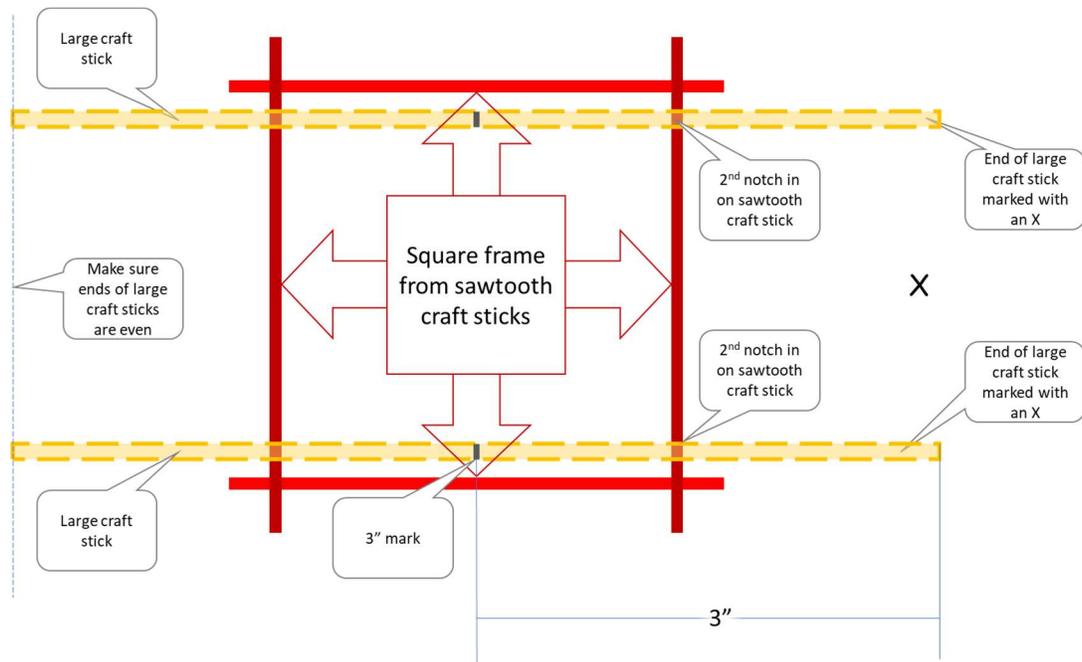
Step 6. Chassis assembly

Parts used: Large craft sticks with holes drilled at either end from step 2 (2), sawtooth craft sticks (4 + 1), popsicle stick (1)

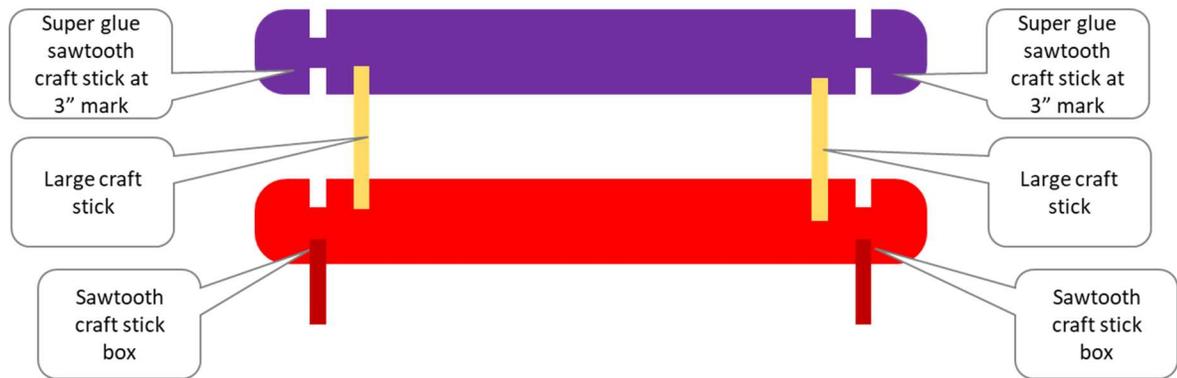
- a) On the two large craft sticks place a mark 3" from one end
 - b) From the same end place a mark 1 ½" from the end
 - c) Place an x by the axel hole on the end you measured from
- Note: your large craft stick may not be exactly 6" long*



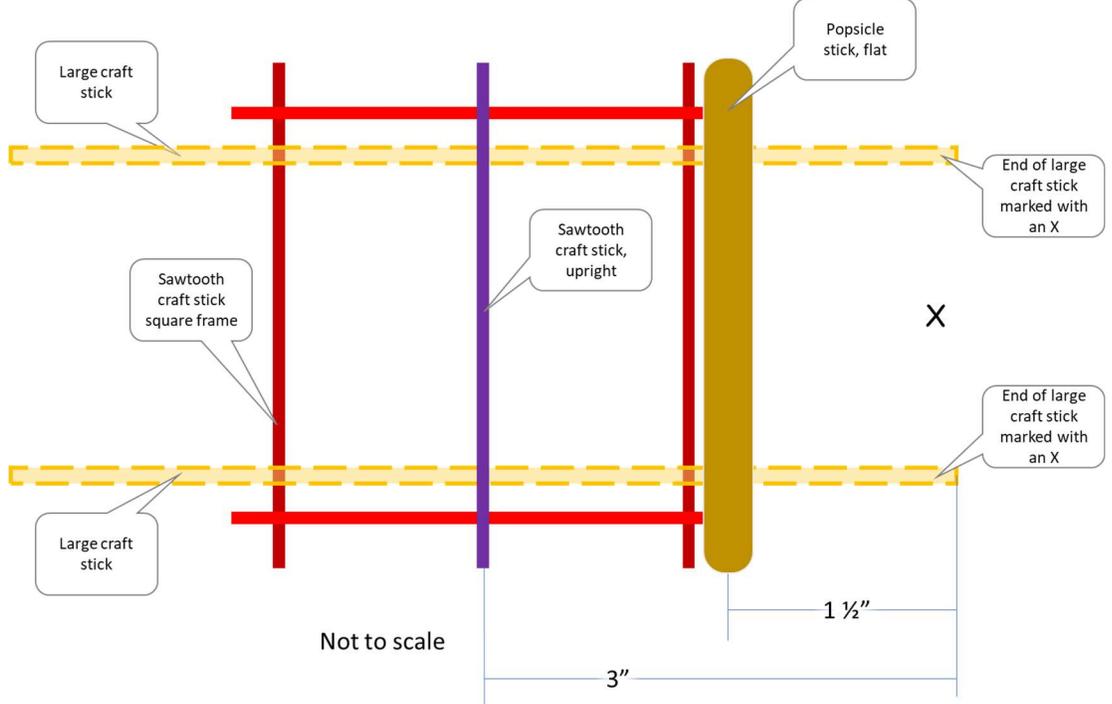
- d) Using 4 sawtooth craft sticks construct a square box by interlocking notches at each end of the sawtooth craft sticks
DO NOT GLUE THE BOX TOGETHER
- e) Place the 2 large craft sticks in the 2nd slots from the ends on the sawtooth craft stick box, parallel to each other, with the X's both at the same end
- f) Make sure that the ends are even



- g) Place a dot of super glue at the 3" mark on each large craft stick
- h) At the 3" mark Insert the notch of a sawtooth craft stick to hold both large craft sticks upright



- i) Place a dot of super glue at the 1 1/2" marks on both large craft sticks
- j) Place a popsicle stick flat across the two large craft sticks



- k) Additional dots of reinforcing super glue can be added to the joints of the popsicle stick and the sawtooth craft stick
- l) Allow glue to dry

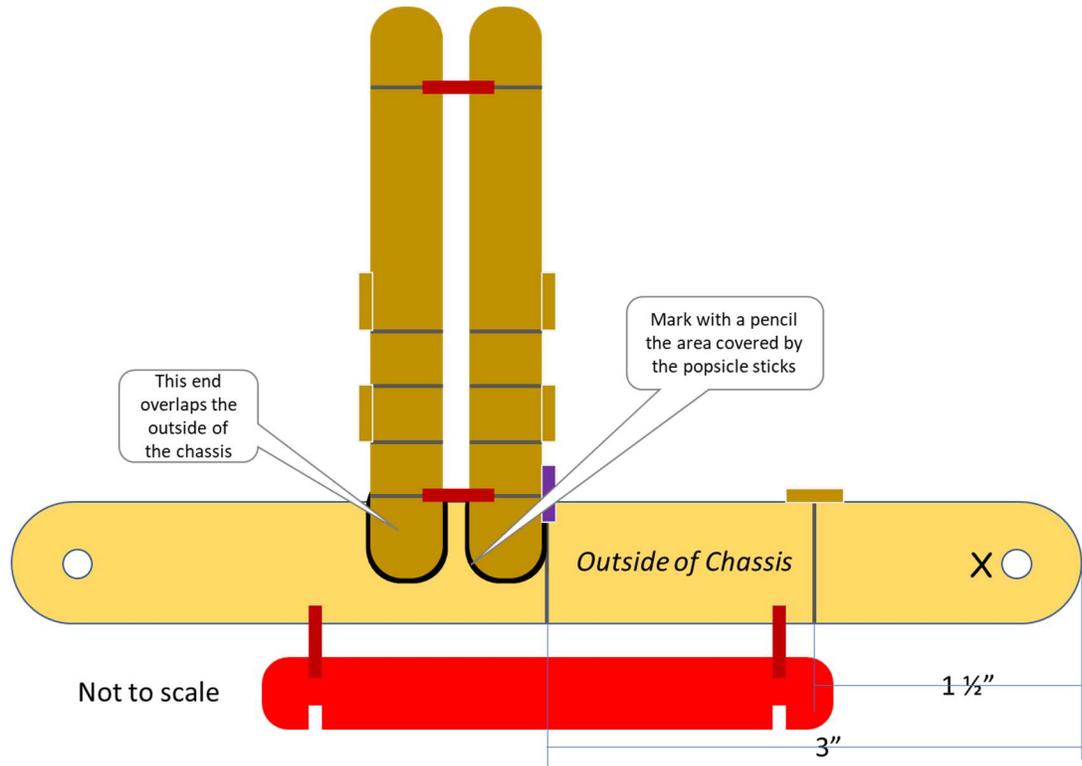
Why we do this: We need a chassis to connect the wheels together with the carrying space. Without a strong frame (chassis) the individual parts would not be able to complete their tasks.

Think:

Step 7. Attaching the carrying space to the chassis

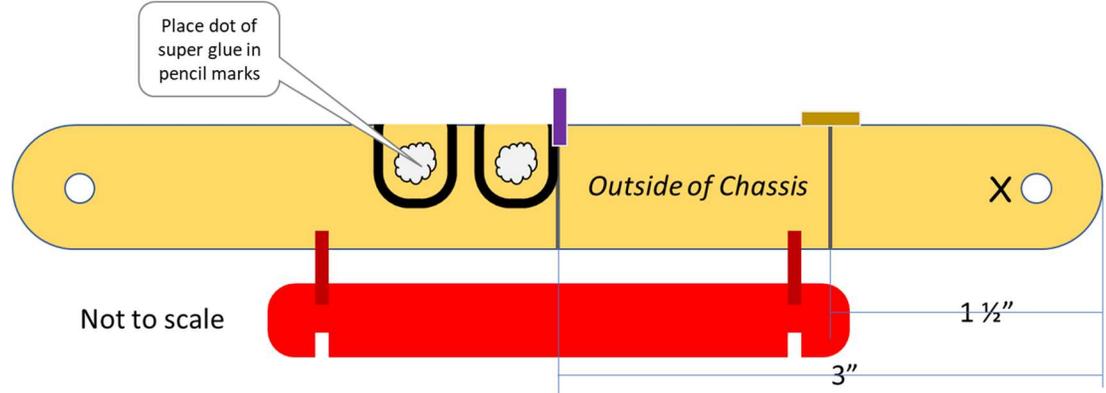
Parts used: Chassis (built in step 6), carrying space (built in step 5), 1 sawtooth craft stick

- a) The carrying space should now be dry, test fit it at the 3" mark against the sawtooth craft stick away from the end with the X, with the 5/8" mark going down against the chassis
- b) The 5/8" ends of the popsicle stick will not fit both on the outside or inside of the chassis, one set will be on the outside and one will be on the inside of the chassis
- c) Using a pencil mark the area where the chassis and carrying space meet on both large craft sticks

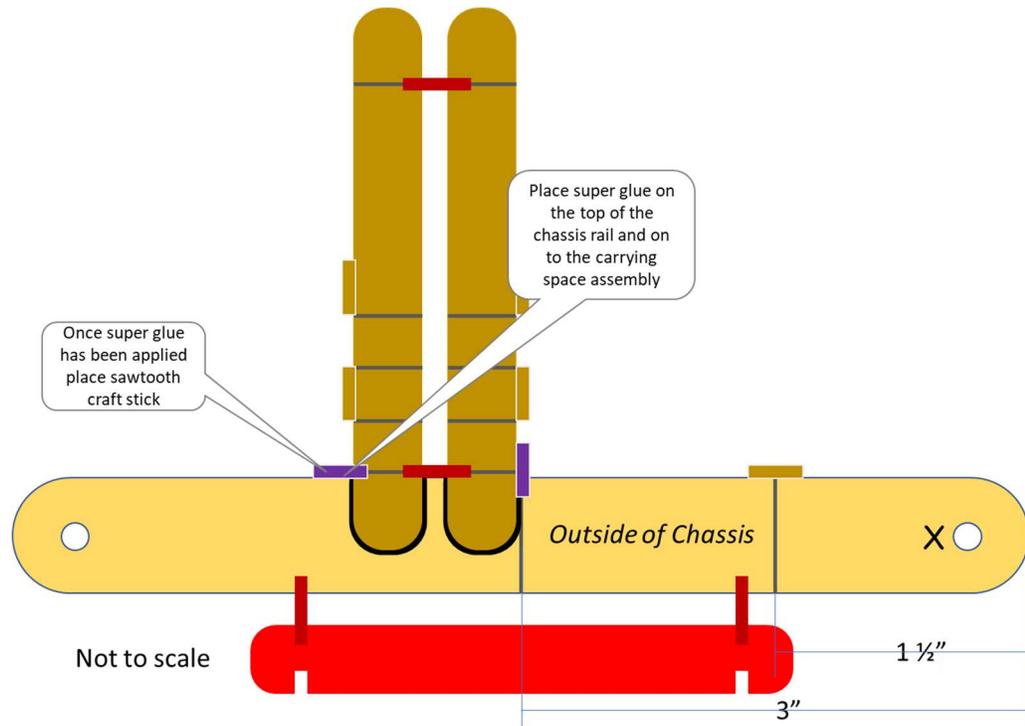


- d) Lift off the carrying space and set aside for a moment

- e) In the area you marked with the pencil on the outside of one large craft stick and the inside of the other large craft stick place dots of super glue



- f) Place carrying space back on chassis and press into super glue marks to secure it to the chassis
- g) Apply a dot of glue to the chassis to the area behind the carrying space smearing it up on to the carrying space frame
- h) Place a sawtooth craft stick so that the notches interlock with the carrying space frame and it sits flat on the chassis



- i) Allow to dry add reinforcing super glue if necessary

Why do we do this: This allows our transporter to haul our cargo (marbles), without this attached we would have no place for our cargo to ride while the transporter moved.

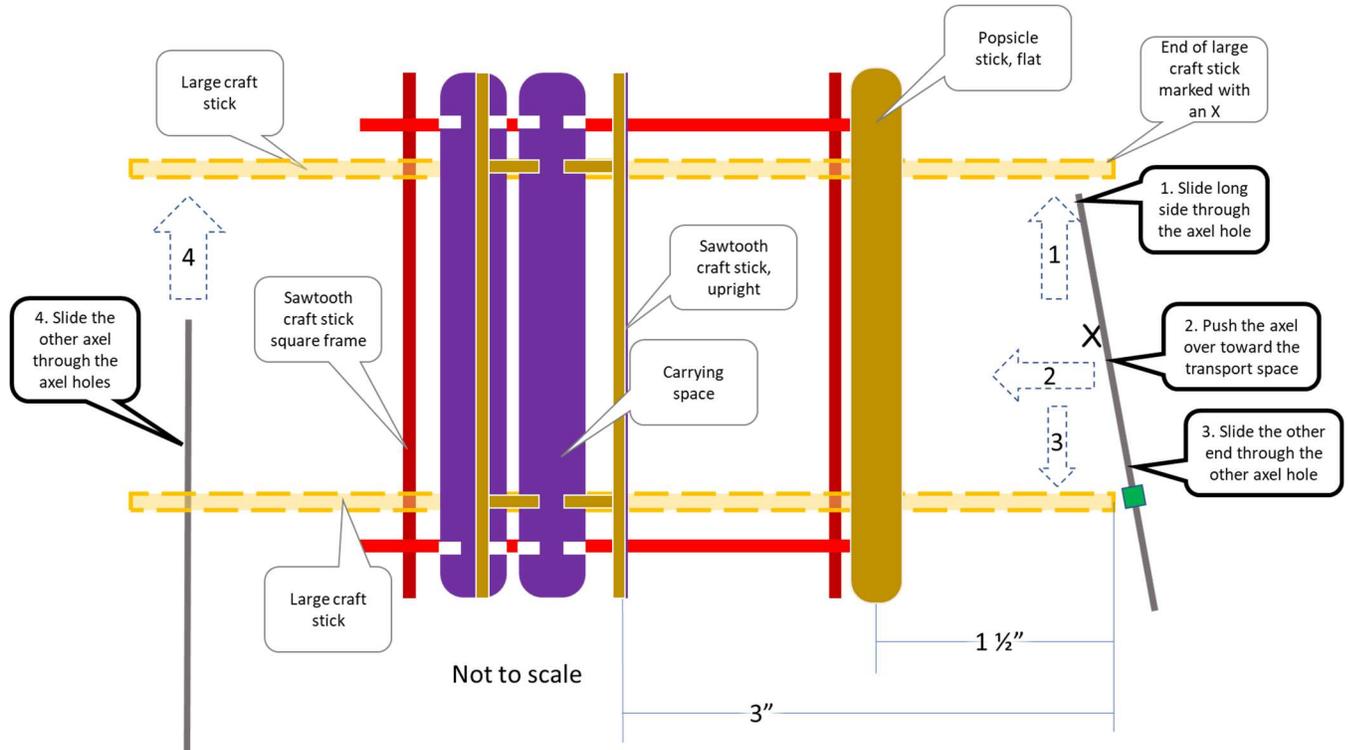
Think: Are there other types of cargo this could transport?

Step 8. Adding wheels and an “engine”

This step is where the rubber meets the road. At this point you will have a functional transport robot.

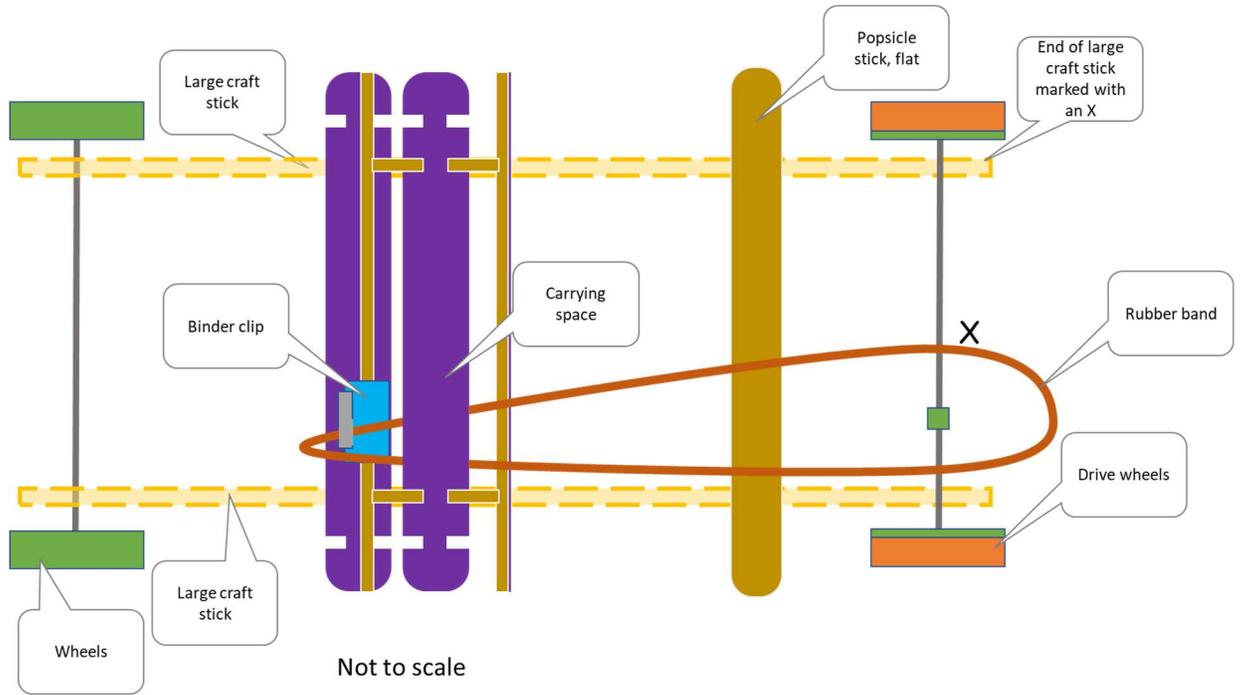
Supplies used: Assembled chassis from step 7, 2x drive wheels from step 1, drive axel from step 3, 2x wheels, 1 axel, rubber band/binder clip from step 4

- a) Take the drive axel feed the longer end through one of inside the axel holes on the end of the chassis with the X
- b) Slide the drive axel back slipping the other end through the axel hole on the other side of the chassis



- c) Slide the other axel through the axel holes on the opposite side of the chassis
- d) Discard sawtooth craft stick square frame
- e) Press the drive wheels on to the drive axel on the end with the X
- f) Press the regular wheels on to the opposite axel
- g) On the topmost popsicle stick on the carrying case furthest from the drive axel (end with the X), clip the binder clip and rubber band so that the ends are sticking up

h) Route the rubber band through the top section of the carrying space to the zip tie on the drive axel



Your transporter is complete and ready to use!!!!

Using your transporter

- Add marbles to the carrying space, you will need at least 8 to get good traction
- Wrap the rubber band attached to the binder clip around the zip tie, by placing it on a surface and pulling back till the rubber band is wound around the axel
- Adjust the transport in the direction you want it to go and release
- It will transport your marbles from the place you released it at to a point further away.

