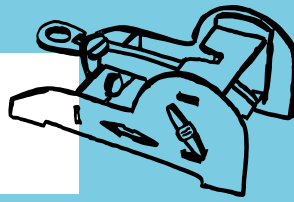


ACTIVITY 1

Are you ready to launch? Projectiles, that is! In this activity, you'll assemble your catapult to be used in the next two activities. As you put the pieces together, can you figure out how this catapult works? What causes the force to increase or decrease?

LET'S MAKE



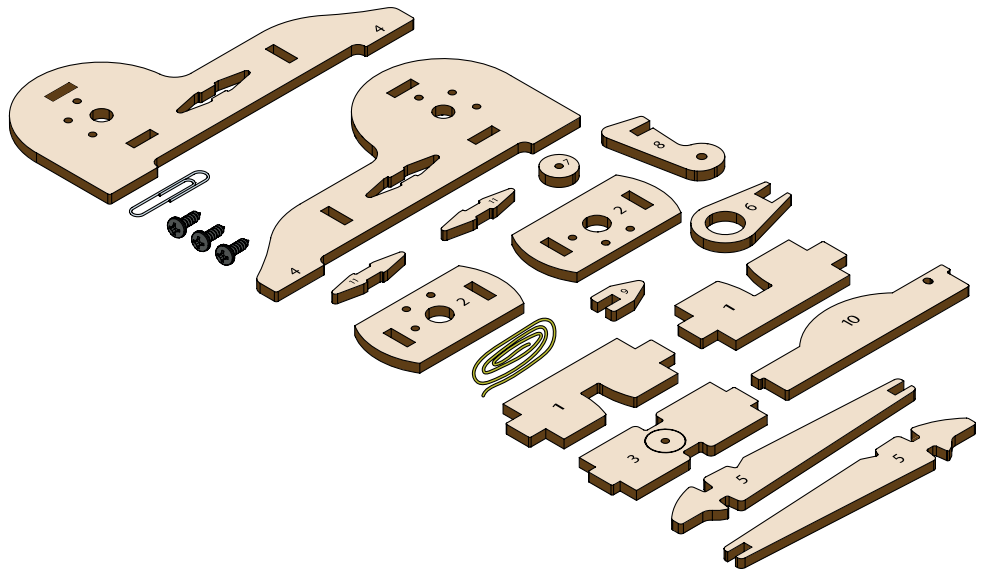
GATHER YOUR SUPPLIES

INCLUDED



SAFETY GLASSES

TORSION CATAPULT KIT



NOT INCLUDED



WHITE GLUE



SMALL PHILLIPS SCREWDRIVER



SCISSORS

Note: Some of these pieces will fit very snugly. Instead of forcing the piece in, which might cause the wood to snap, try wiggling the piece into its place. If it still does not fit, try sanding it down with sandpaper or a nail file.

BUILD THE CATAPULT FRAME

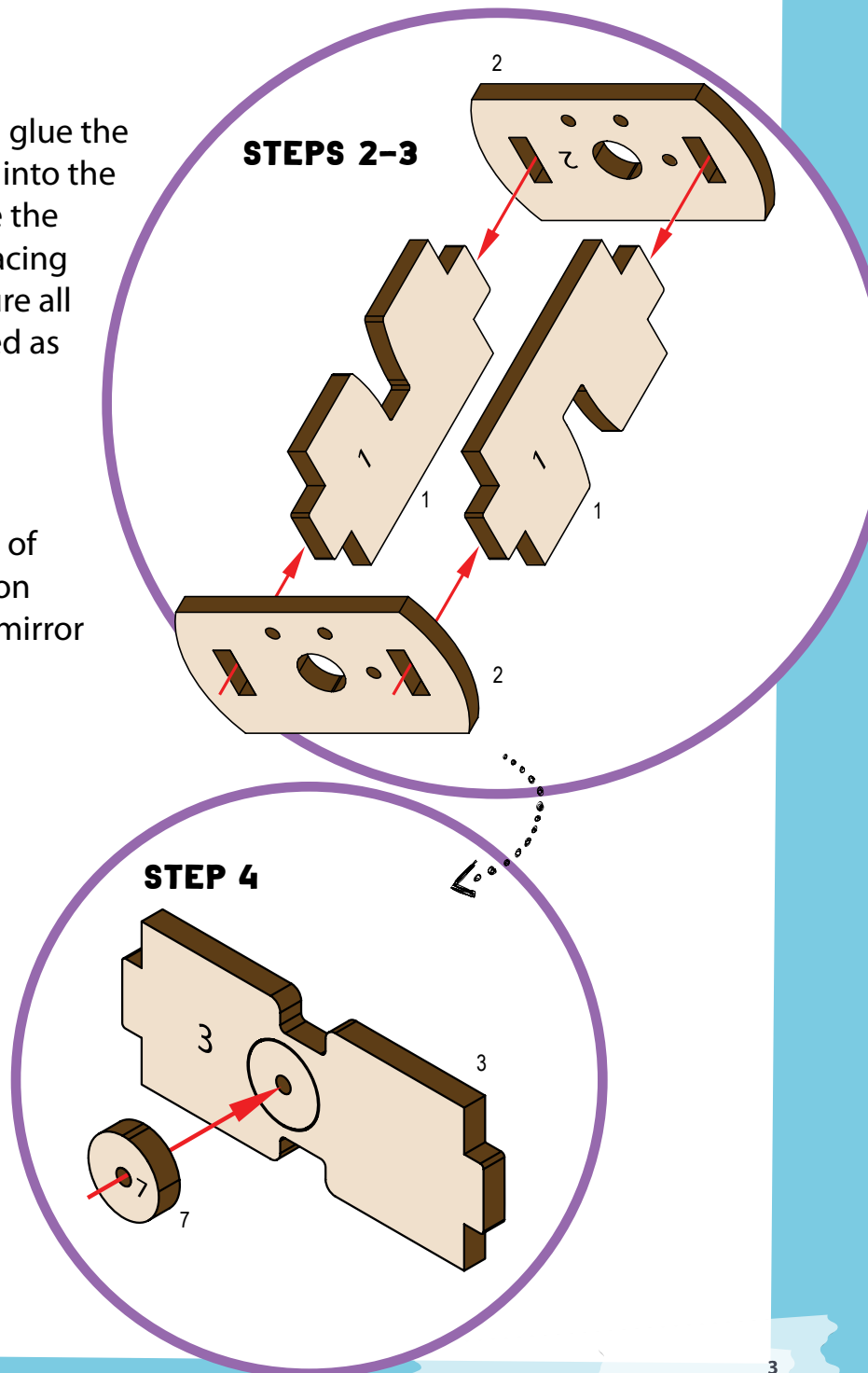
Note: Don't throw away anything until your build is complete, just in case you missed a small part!

STEP 1
Pop out the parts from the basswood sheets.

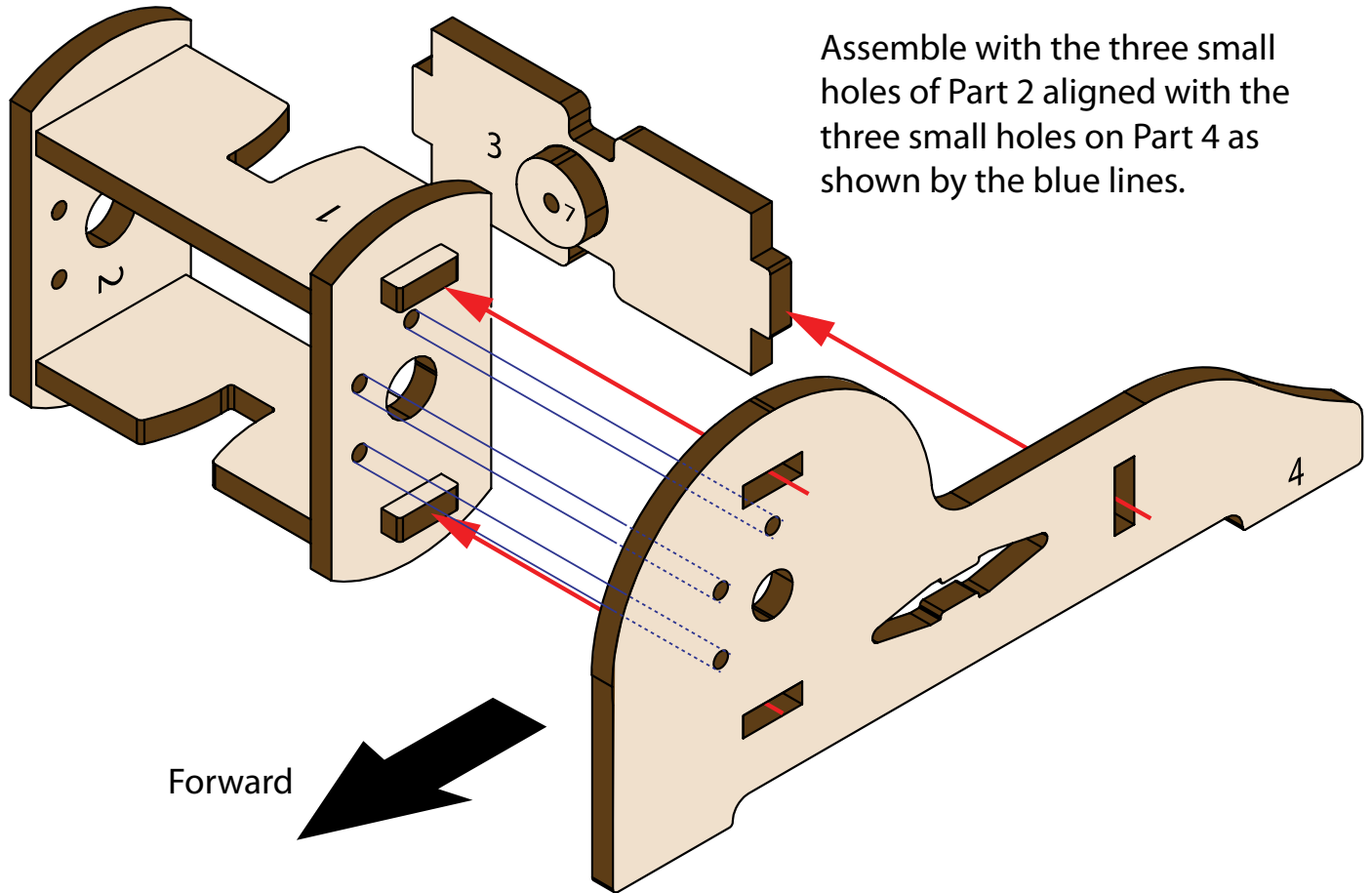
STEP 2
Place a Part 2 facedown and glue the notches of the Part 1 pieces into the Part 2 as shown – make sure the grooves on the Part 1s are facing in opposite directions. Be sure all the Parts 1 and 2 are oriented as shown in the image.

STEP 3
Glue the other Part 2 on top of the Part 1s. The small holes on the Part 2 pieces should be mirror images. Let dry.

STEP 4
Glue Part 7 over Part 3 where the circle indicates. Be careful not to get glue in the small hole in the middle of the two parts. Let dry.



STEPS 5-6



STEP 5

Glue the Part 1 notches that extend from one side of Part 2 into the slots of Part 4. Be sure the small circles on Part 2 are matched to the small circles on Part 4. Also, make sure the groove on the bottom Part 1 is facing forward.

STEP 6

Now, glue the notch on one end of Part 3 into the single slot on the narrow end of a Part 4. Part 7 on the assembly should face the center of the catapult.

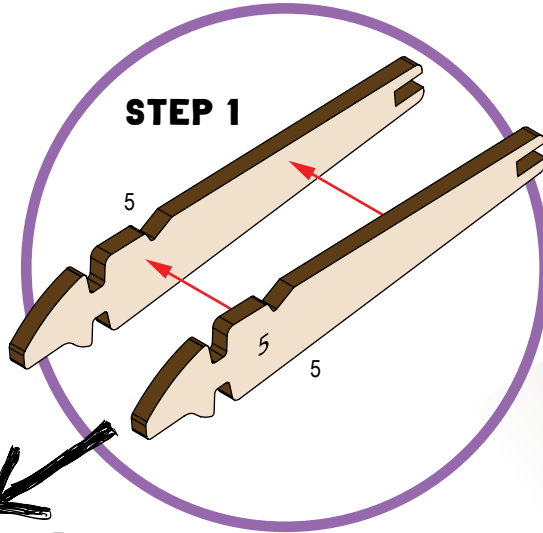
STEP 7

Glue the other Part 4 on top of the two assemblies so the two Part 4s are even.

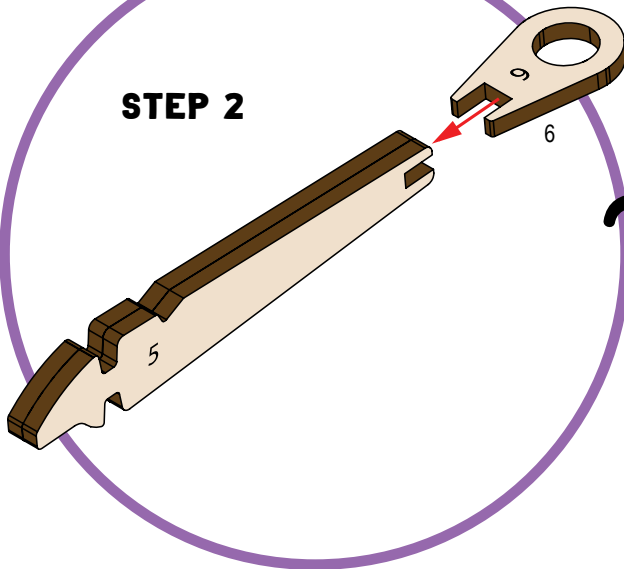
MAKE THE LAUNCH ARM AND TRIGGER FRAME

STEP 1

Parts 5 and 6 make the launch arm. Glue the two Part 5s back-to-back.



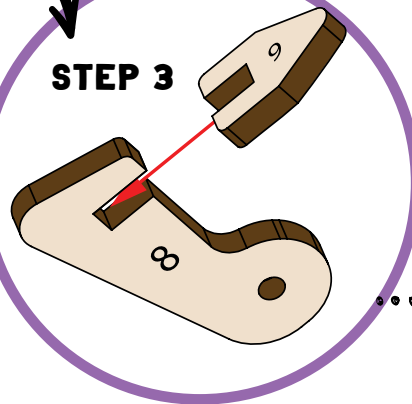
STEP 2



STEP 2

Glue Part 6 into the notch on the end of the Part 5s. Let dry.

STEP 3

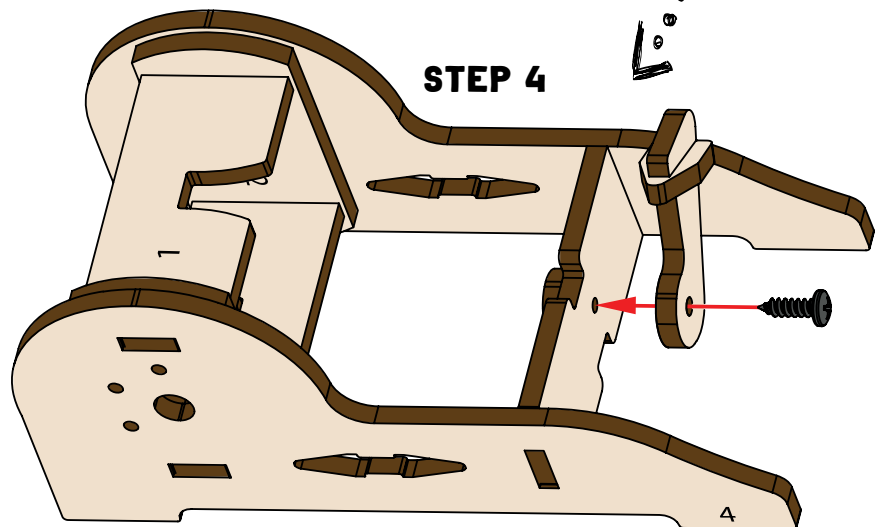


STEP 3

Parts 8 and 9 make the trigger. Glue them together by fitting the slot in Part 9 into the slot on Part 8. Let dry.

STEP 4

On the back of the catapult, screw on the trigger so it points toward the center of Part 3.

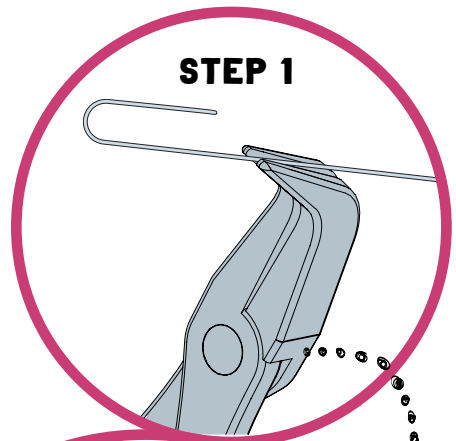


ADD THE TORSION STRING



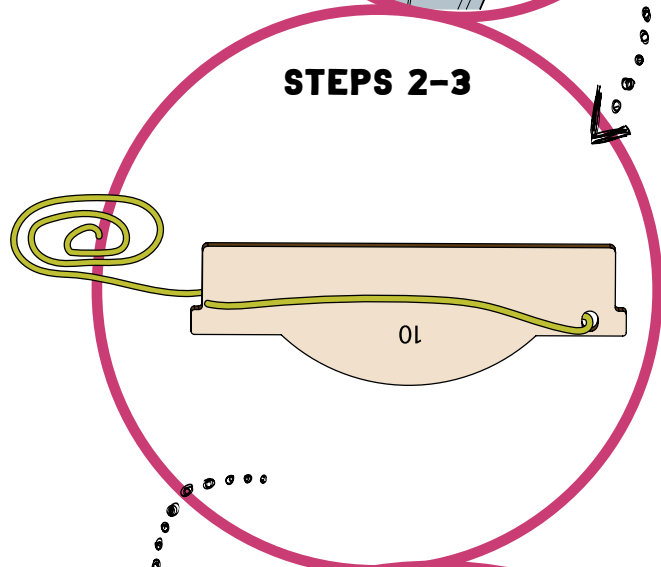
STEP 1

Straighten the paper clip except for a hook at one end.



STEP 2

Locate Part 10 and the string. This part will help create the loops of string that will be needed for the torsion component of the catapult.



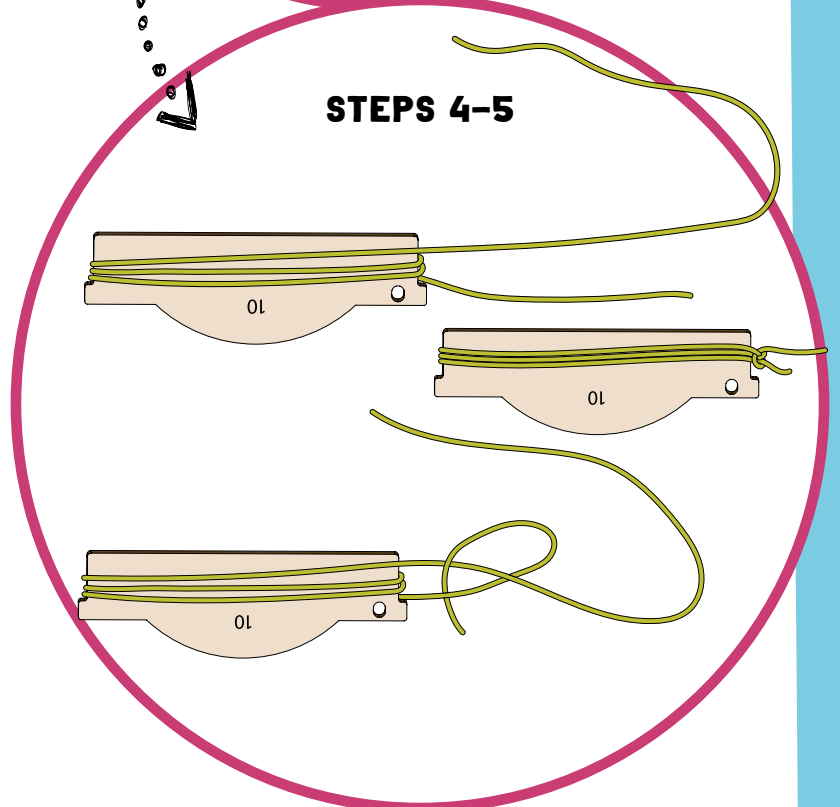
STEP 3

Take one end of the string and thread it through the hole on Part 10. Pull out enough string to equal the length of Part 10.



STEP 4

Loop the string around Part 10 three times so you have three complete loops. Pull the string from the hole so you have two loose ends.



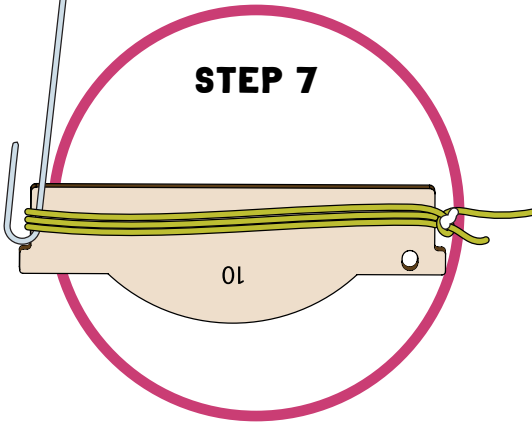
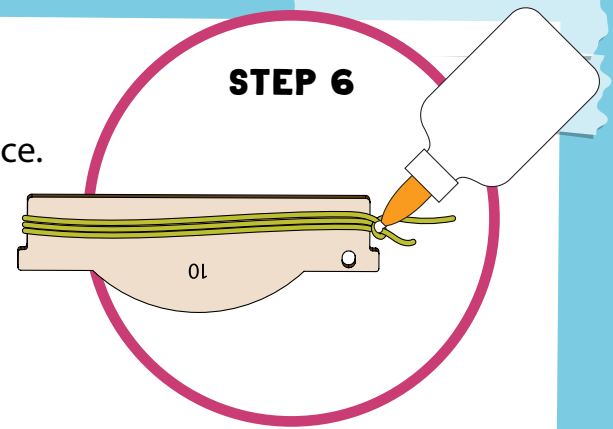
STEP 5

With the string still wrapped around Part 10, pull the string out of the hole. Now, take the two ends of the string and tie them in a knot.



STEP 6

Place a dot of glue on the knot to hold it in place.
Let it dry.



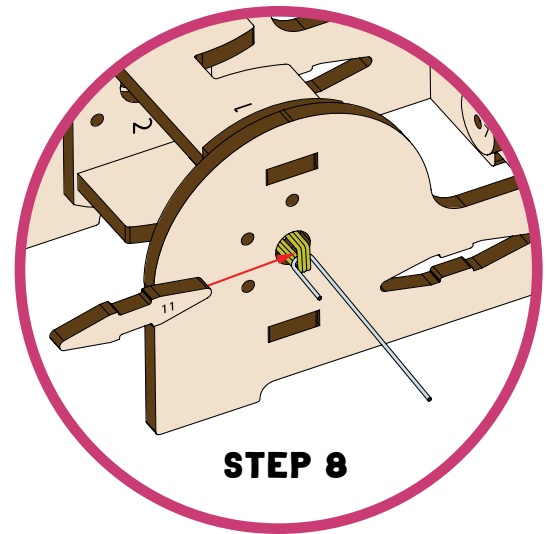
STEP 7

Use the paper clip to remove the knotted and glued string from Part 10.

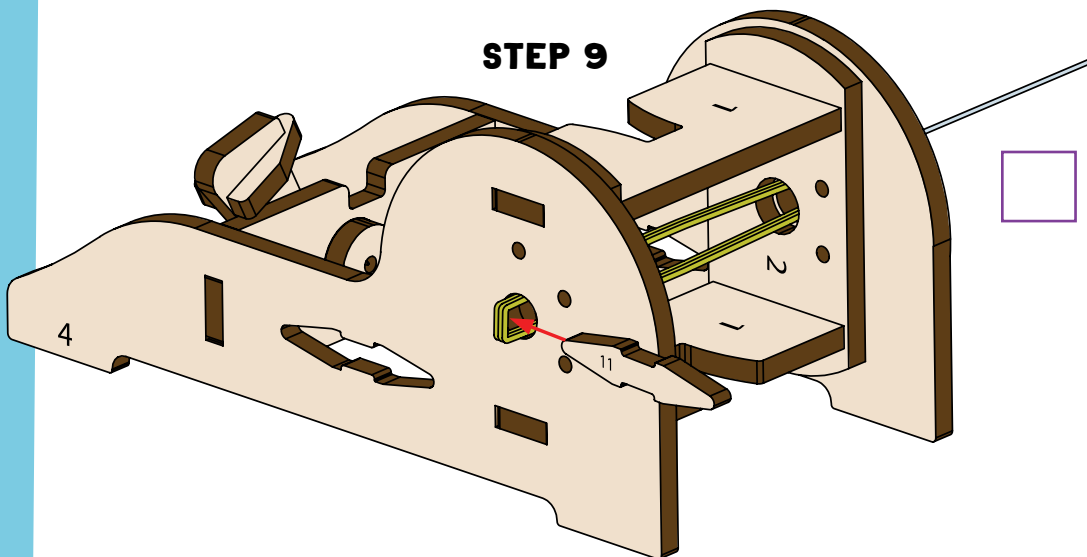


STEP 8

Use the paper clip to thread the string through the big hole on one side of the catapult, taking the paper clip out the opposite hole. Do not pull the string all the way through – leave a loop of string hanging out the end. Insert a Part 11 (keeper) into the loop.



STEP 9



STEP 9

Pull the string tight. Under the loop with the paper clip, insert another keeper. Remove the paper clip. Trim the string ends.

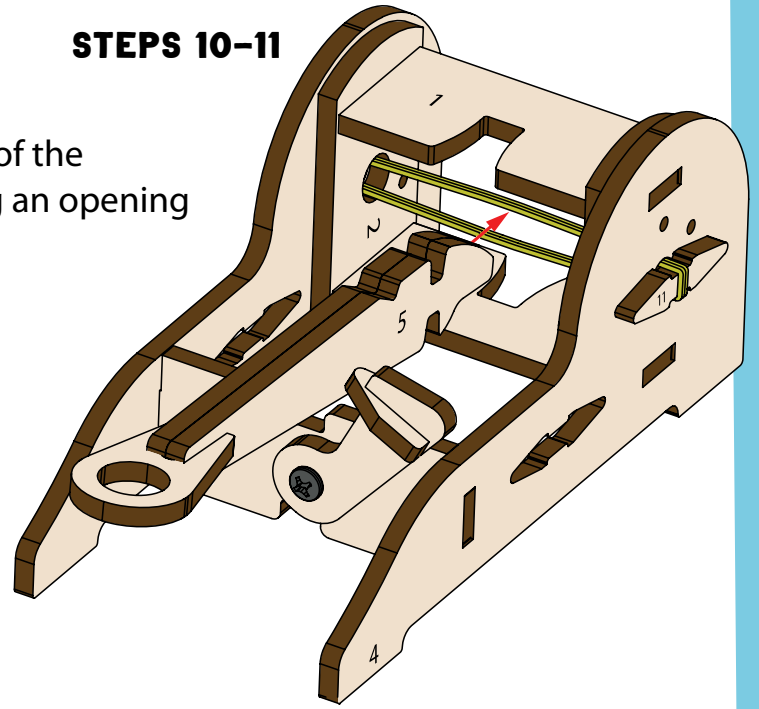
STEPS 10-11

STEP 10

Separate the strings in the middle of the catapult into two sections, keeping an opening between them.

STEP 11

From the back of the catapult, insert the launch arm into this opening as shown. The other end should rest on the back of the catapult body.



STEP 12

Place the catapult so the front is away from you. Holding the keeper and string on the right side still, give the keeper on the left side one turn counterclockwise.

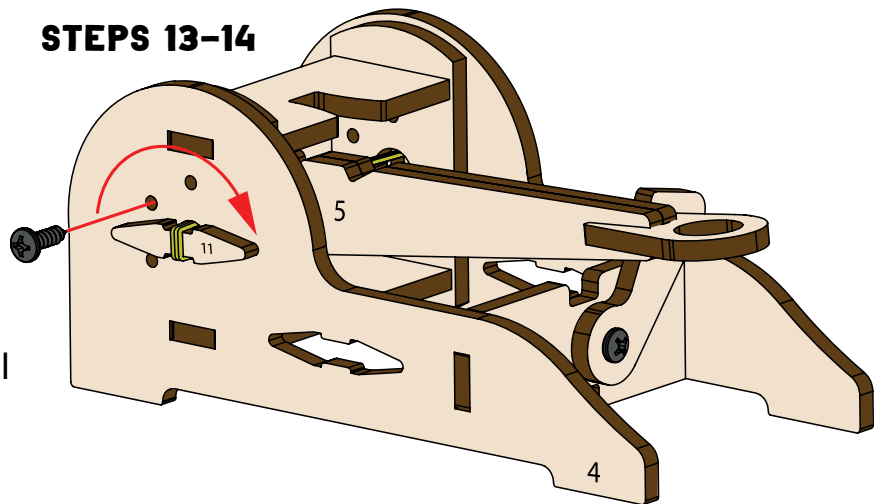
STEP 13

Next, hold the left keeper still and turn the keeper on the right one turn clockwise. Note that these go in the opposite direction – that is what twists the string, providing torsion.

STEPS 13-14

STEP 14

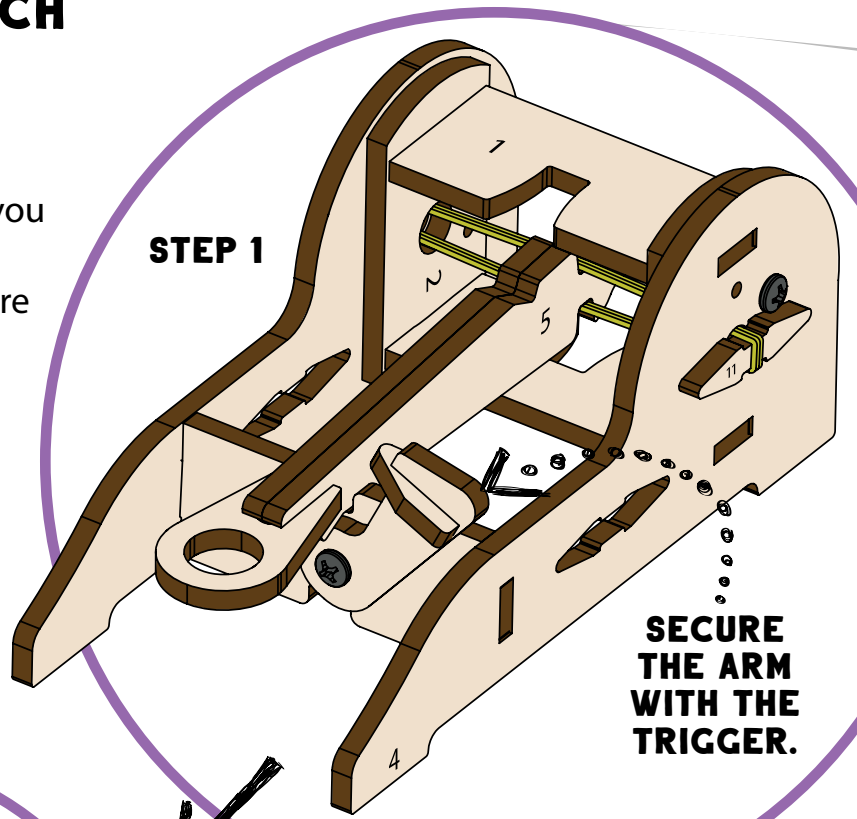
Now repeat this procedure, but just give each side a half turn. Place a screw into the hole on each side that will enable the screw to best hold the keeper in place. This will vary depending on how tight the string is wound. The tightness of the string will determine the tension in the catapult. The tighter the string, the higher the tension.



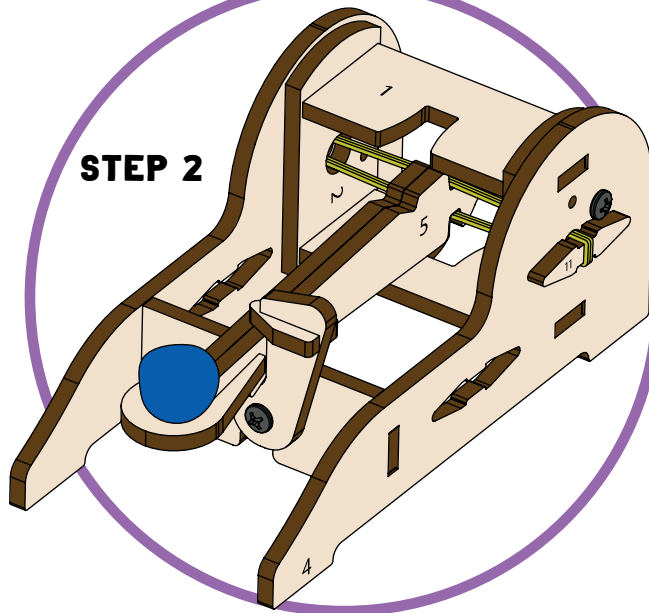
GET READY TO LAUNCH

STEP 1

Place the catapult where you wish to launch it. Pull the launch arm back and secure it with the trigger.

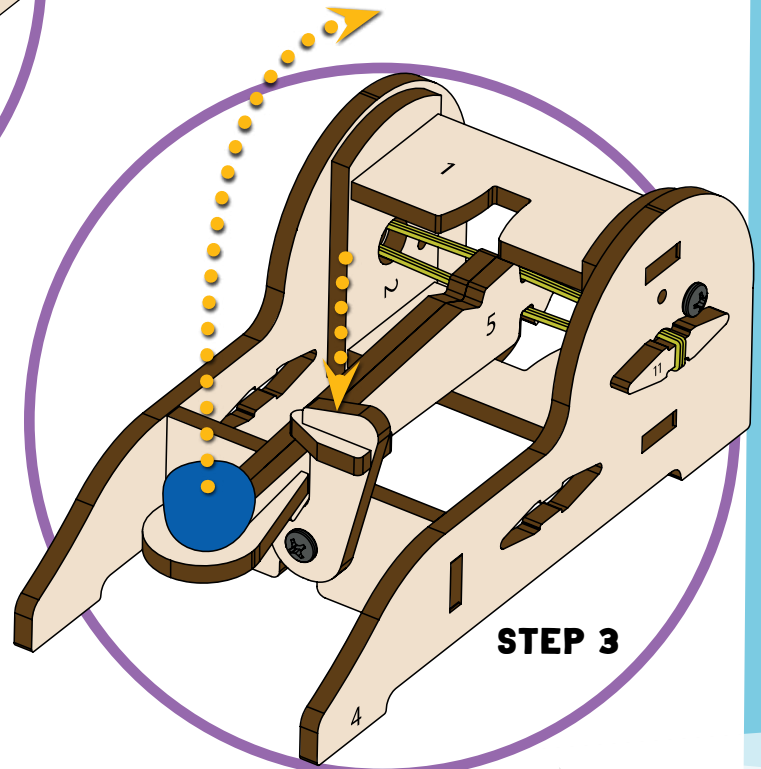


STEP 2



STEP 2

Place a projectile on the hole of the launch arm.



STEP 3

To launch, pull down the trigger.

Tip: Use more tension for heavier projectiles and less tension for lighter ones.



SAFETY

- Anyone operating the Torsion Catapult or nearby during its operation should wear safety glasses.
- Never use a sharp object as a projectile. Never fire at a living thing.
- Use this device only in the manner discussed and illustrated within this guide. Misuse of this product can cause serious injury.
- Make sure the launch site and flight path are clear of all people prior to launch.

THINK ABOUT IT



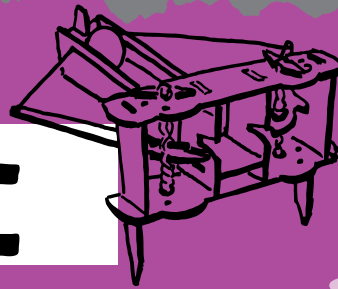
Check out the “STEAM On DREAM On” section of this guide to learn about the different classes of levers. Can you identify which class this catapult is? Where is the fulcrum, load, and effort?

Research about torsion catapults. When were they first used and by whom?



ACTIVITY 1

Get ready to build! In this activity, you'll assemble the torsion ballista that you'll use throughout the next two activities. As you build, think about how much work it must have been to build a ballista big enough to throw a 60 lb ball up to 500 yards!



LET'S MAKE

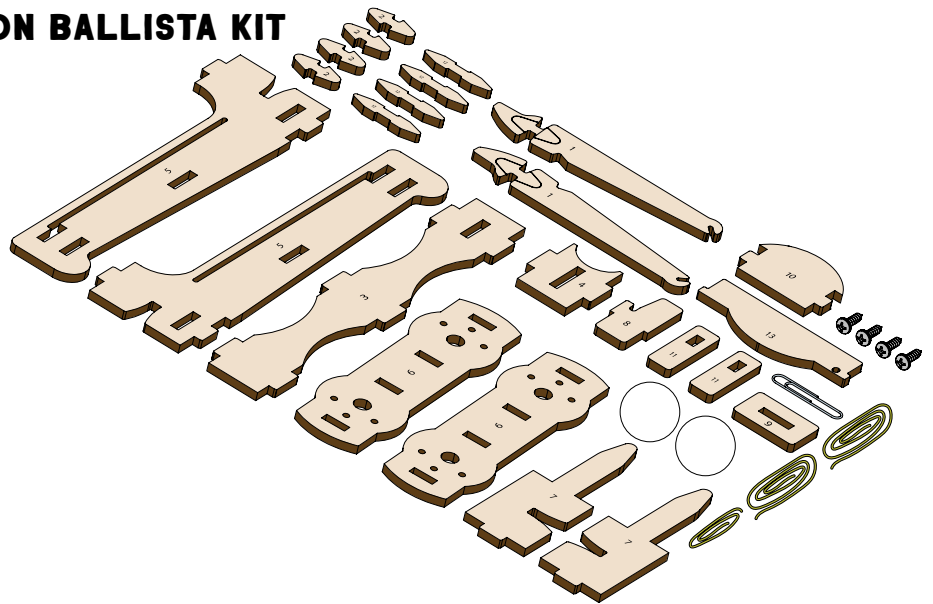
GATHER YOUR SUPPLIES

INCLUDED

TORSION BALLISTA KIT



**SAFETY
GLASSES**



NOT INCLUDED



WHITE GLUE



SMALL PHILLIPS SCREWDRIVER



SCISSORS

Note: As you build, you can sometimes move ahead and build while the glue dries for previously built pieces. Before using one of these parts further in the build, make sure the glue is completely dry.

ASSEMBLE THE BOW ARMS

STEP 1

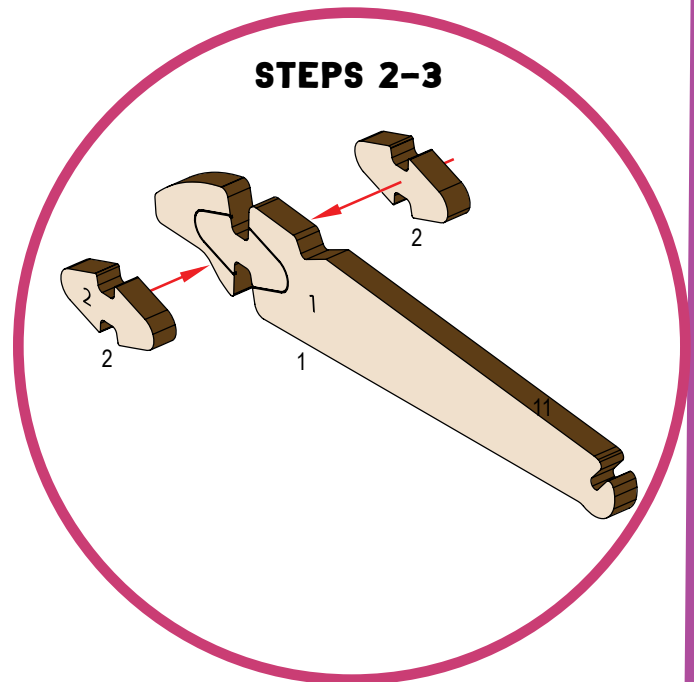
Pop out the parts from the basswood sheets. Note they are numbered for construction purposes.

STEP 2

Lay a Part 1 faceup. Glue a Part 2 over the notched area on the outline that fits Part 2. Repeat this for another Part 1 and 2.

STEP 3

When the glue is dry, turn over each Part 1 and glue another Part 2 on the other side as shown. Let dry.



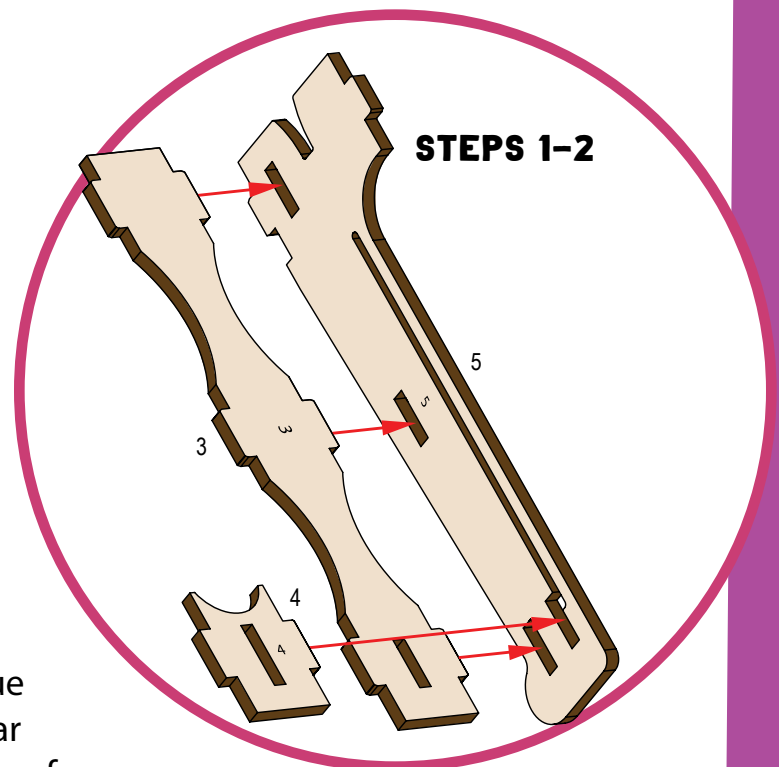
BUILD THE HOUSING FRAME

STEP 1

Take one Part 5, and glue Part 3 into the three notches so it is perpendicular to Part 5. Make sure the slot in Part 3 is toward the narrow end of Part 5.

STEP 2

On Part 5 is a long, narrow slot. Glue Part 4 into this so it is perpendicular to Part 5. Make sure the curved side of Part 4 faces as shown.





STEP 3

Glue the other Part 5 on top of Parts 3 and 4 so it is parallel to the first Part 5.



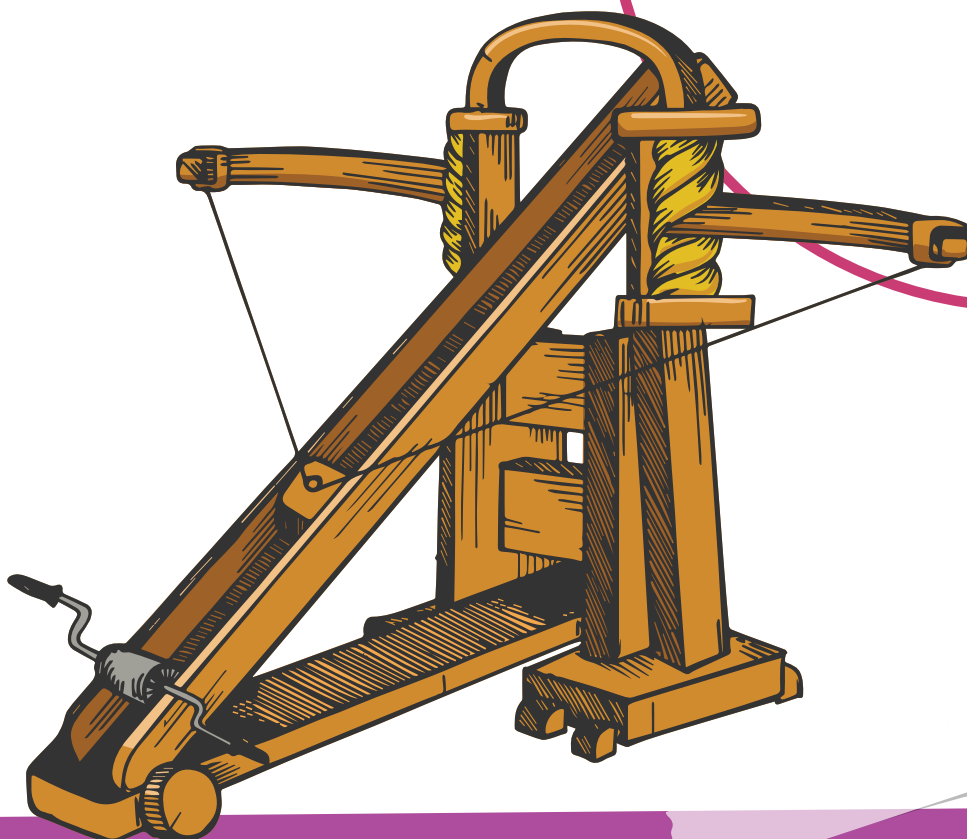
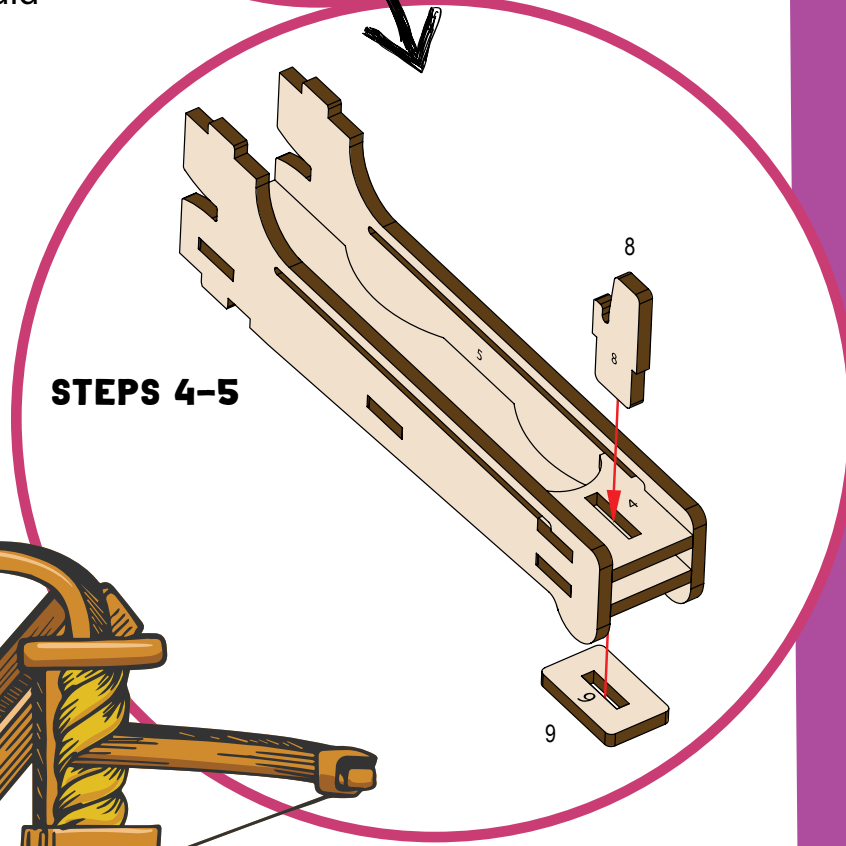
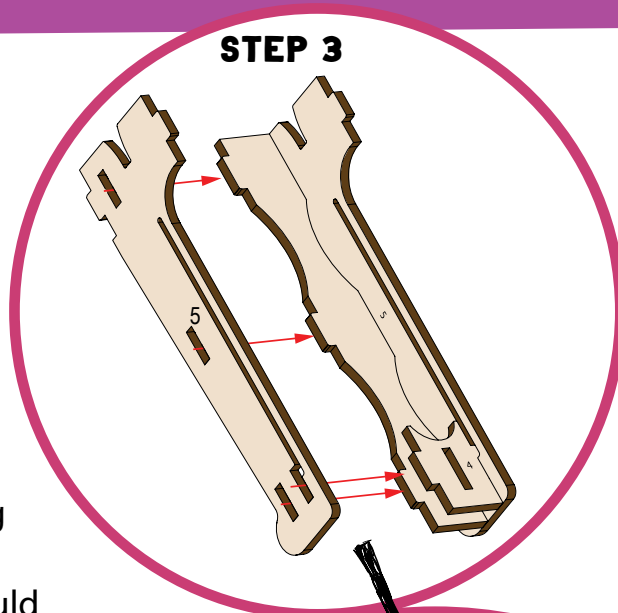
STEP 4

Without glue, insert the square end of Part 8 into the groove on Part 4 of the housing frame. The top of Part 8 has a hook cut into it – the hook should face the inside of the frame.



STEP 5

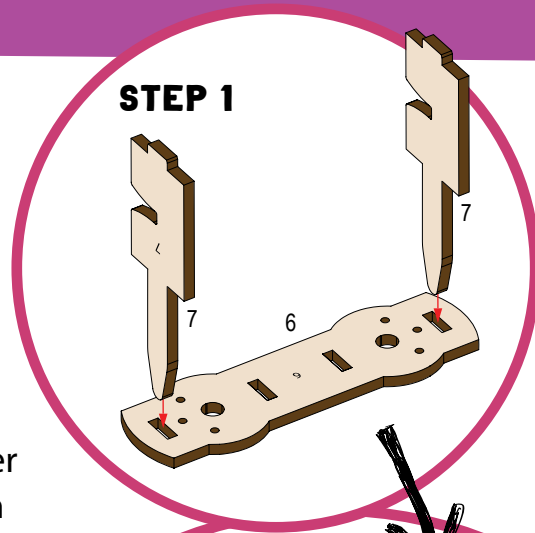
Under the frame, Part 8 will extend a bit – place Part 9 over it. Push up on them until the bottom of the Part 8 hook is level with Part 4. Add a dab of glue around the outside of Part 9. Let dry.



ADD THE BOW ARM FRAME

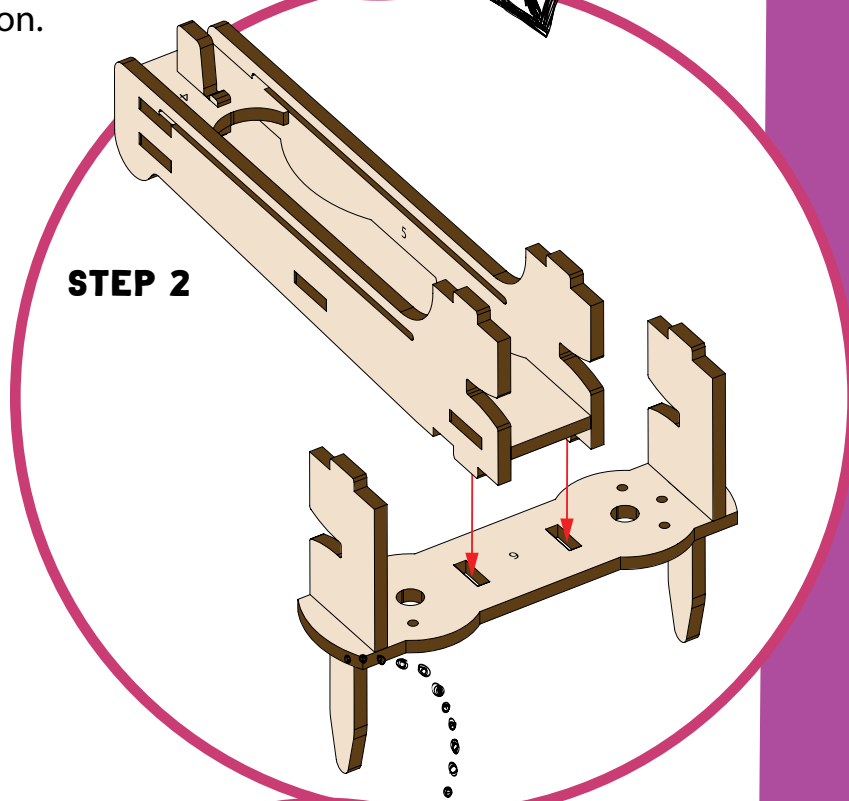
STEP 1

Take a Part 6 and glue the leg of Part 7 into a slot on one of the ends of Part 6. Repeat with the other Part 7 in the other end of Part 6. Make sure the notches on each Part 7 face the same direction.



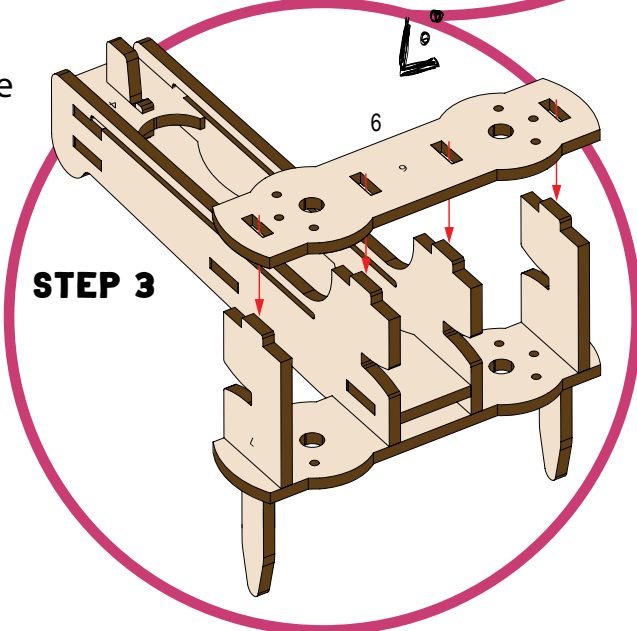
STEP 2

Glue the notches on the bottom front of the housing frame into the slots of the Part 6 that has the Parts 7 attached. Do this so the Part 7 notches face the back of the ballista.



STEP 3

Glue the other Part 6 on top of the four notches of Parts 7 and the housing frame. Let dry.

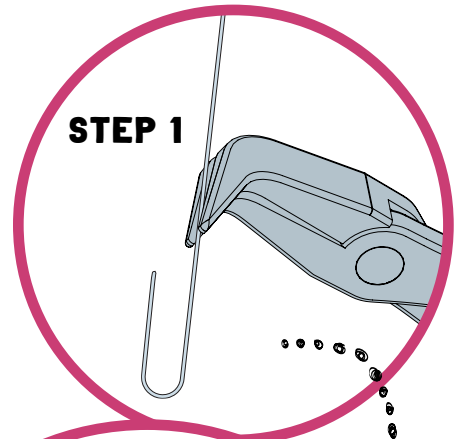


ATTACH THE TORSION STRING



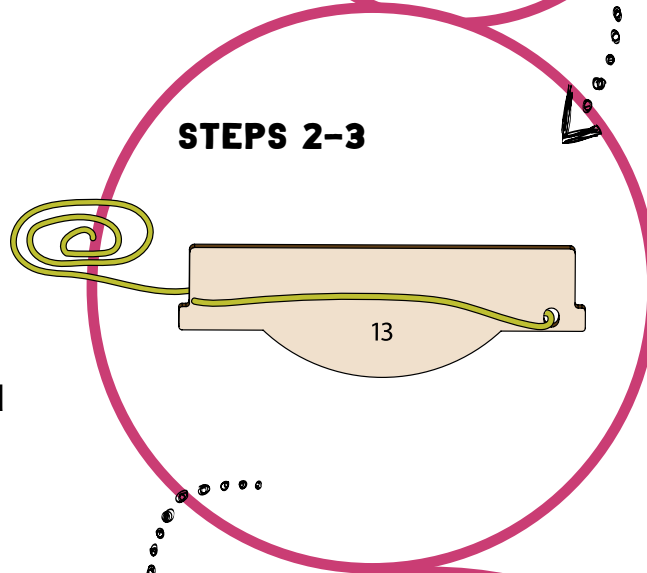
STEP 1

Straighten the paper clip except for a hook at one end.



STEP 2

Locate Part 13 and the string. This part will help create the loops of string that will be needed for the torsion component of the ballista.



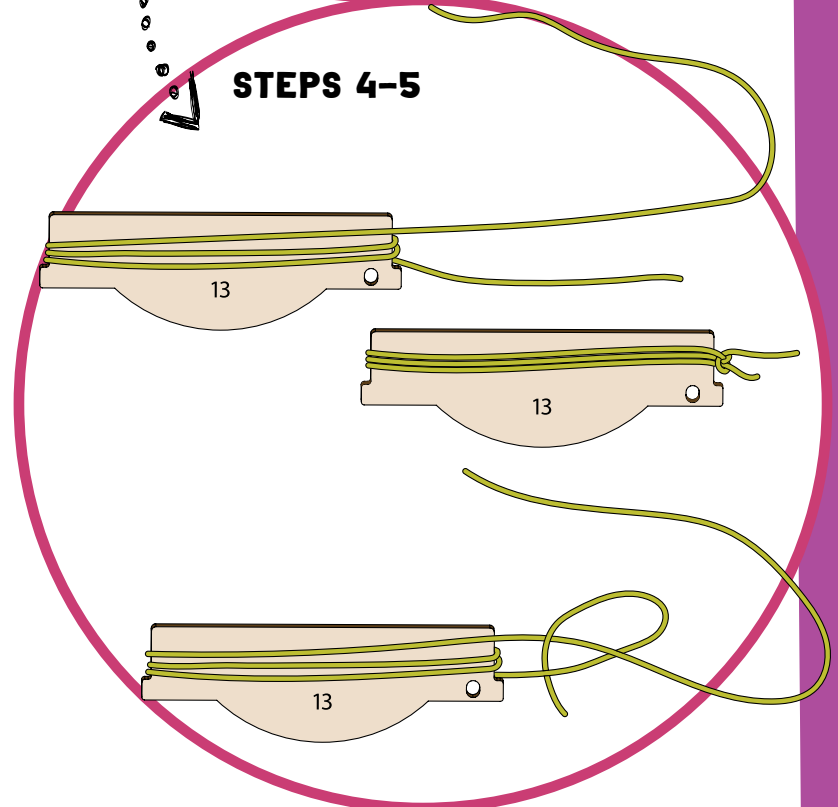
STEP 3

Take one end of the string and thread it through the hole on Part 13. Pull enough string to equal the length of Part 13.



STEP 4

Loop the string around Part 13 three times so you have three complete loops.



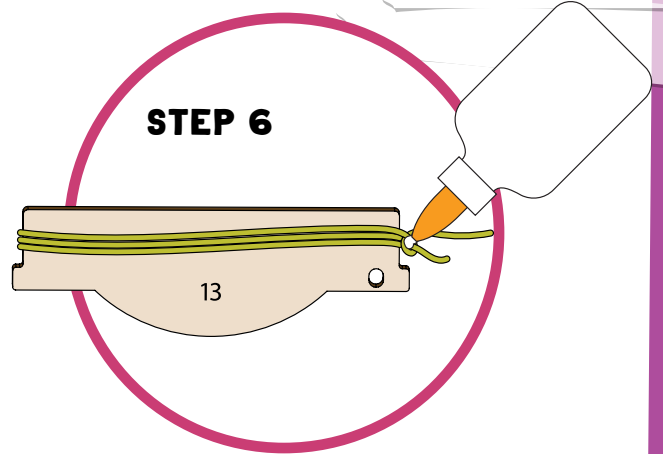
STEP 5

With the string still wrapped around Part 13, pull the string out of the hole. Now, take the two ends of the string and tie them in a knot.



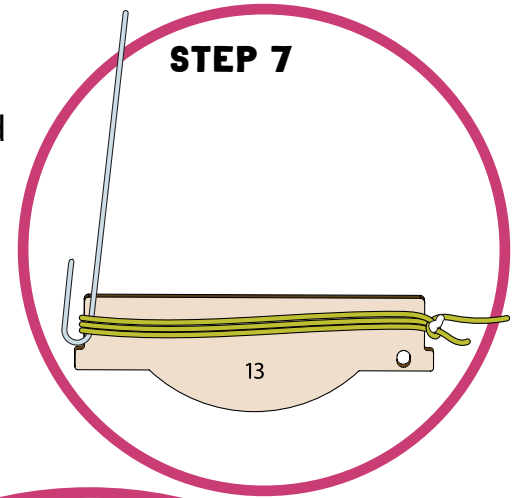
STEP 6

Place a dot of glue on the knot to hold it in place. Let it dry.



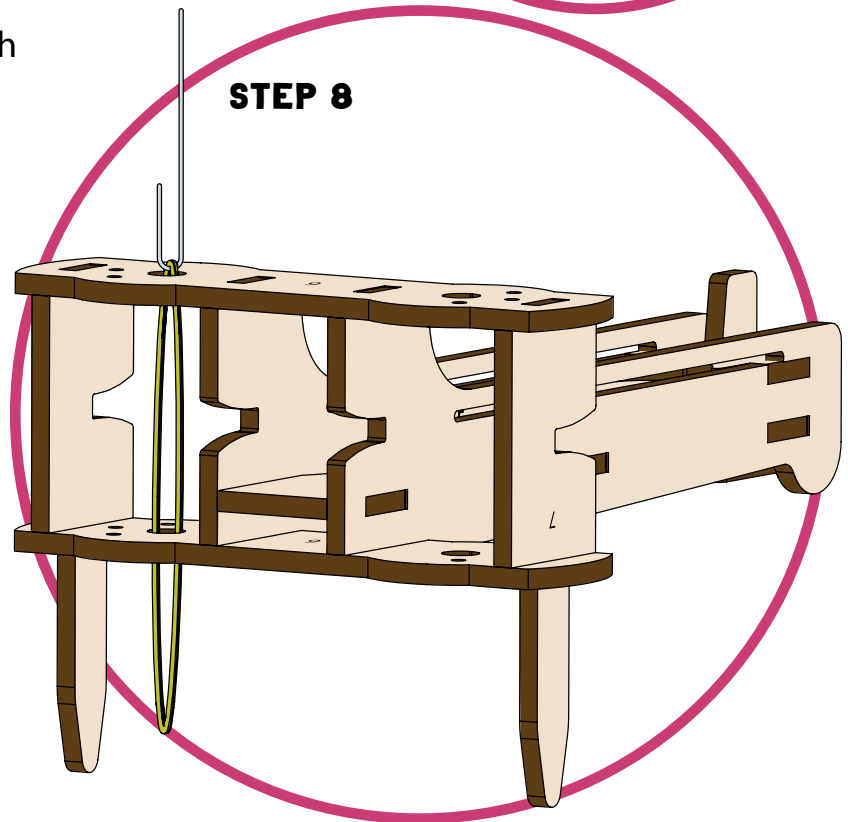
STEP 7

Use the paper clip to remove the knotted and glued string from Part 13.



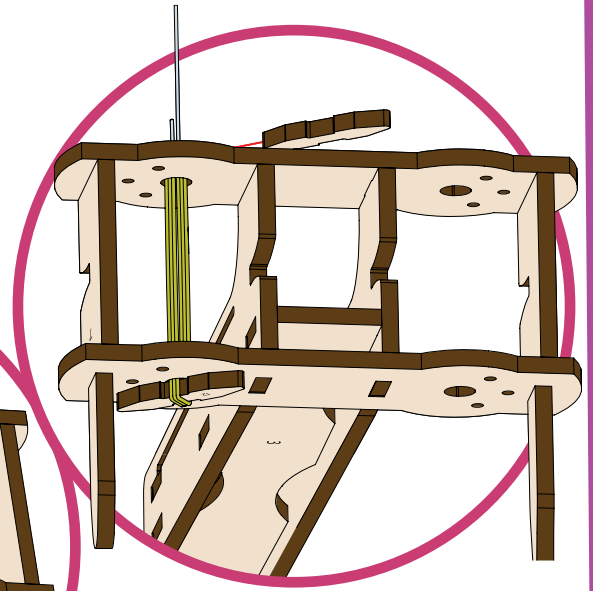
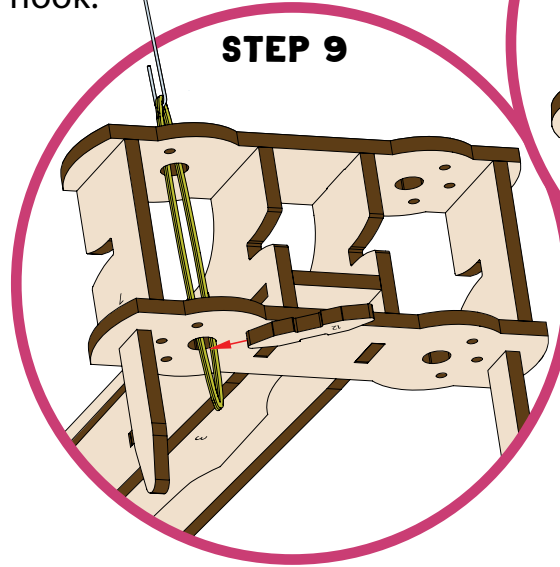
STEP 8

Use the paper clip to thread the string through one of the big holes on top of the bow arm frame, taking the paper clip out the opposite hole as shown. Do not pull the string through all the way – leave a loop of string above the frame.



STEP 9

Insert a Part 12 (keeper) into the loop. Pull the string tight. With the loop on the end with the clip hook, insert another keeper. Remove the hook.



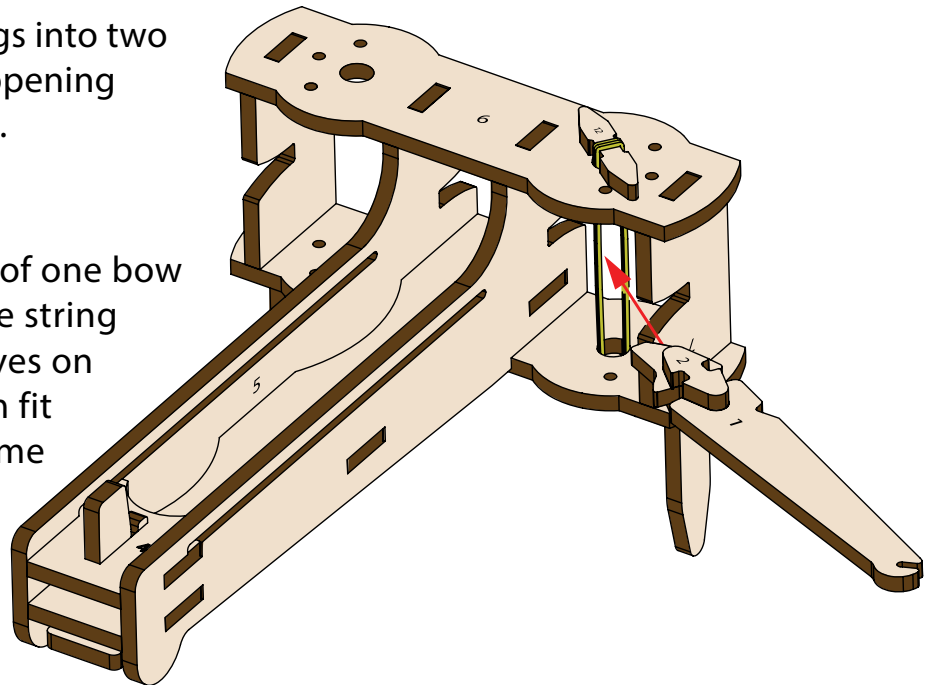
STEP 10

Separate the six strings into two sections, making an opening between the sections.

STEP 11

Insert the wider end of one bow arm in between these string sections so the grooves on either side of the arm fit into the bow arm frame as shown.

STEPS 10-11



STEP 12

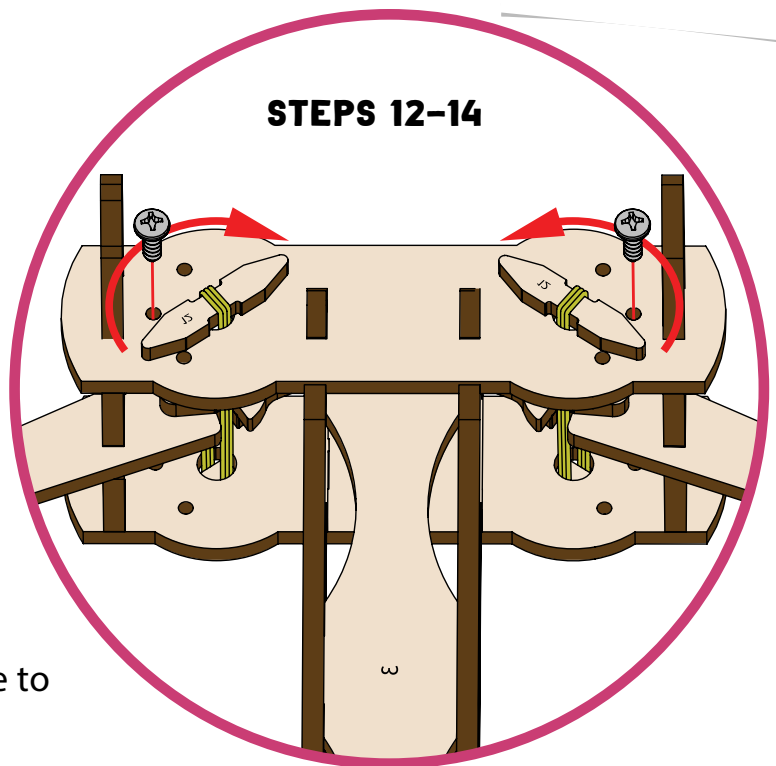
Turn the string keeper on top one time in the opposite direction that the bow arm works (for the right arm, turn counterclockwise; for the left arm, turn clockwise). Holding the top keeper in place, turn the bottom keeper one time in the same direction as the top.

STEP 13

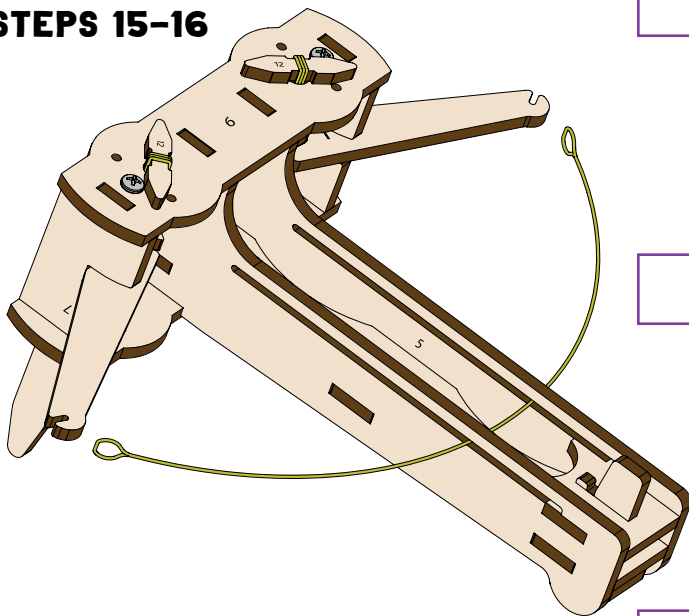
Place a screw on the top and bottom of the bow arm frame to hold the keepers in place.

STEP 14

Repeat the procedure in Steps 2-13 for the other side of the ballista, making sure to turn the string clockwise. Try to make the tension between the two arms even.



STEPS 15-16



STEP 15

Take the extra string and tie one end around the groove at the end of a bow arm. Thread the string through the long narrow grooves on Parts 5.

STEP 16

Tie the other end to the other bow arm so the string is snug and pulling back the arms just a few millimeters. Make sure the bow arms are even and then apply some glue to the string knots.

STEP 17

If needed, remove the screws and even the tension in the two bow arms. Then, replace the screws.

GET READY TO LAUNCH



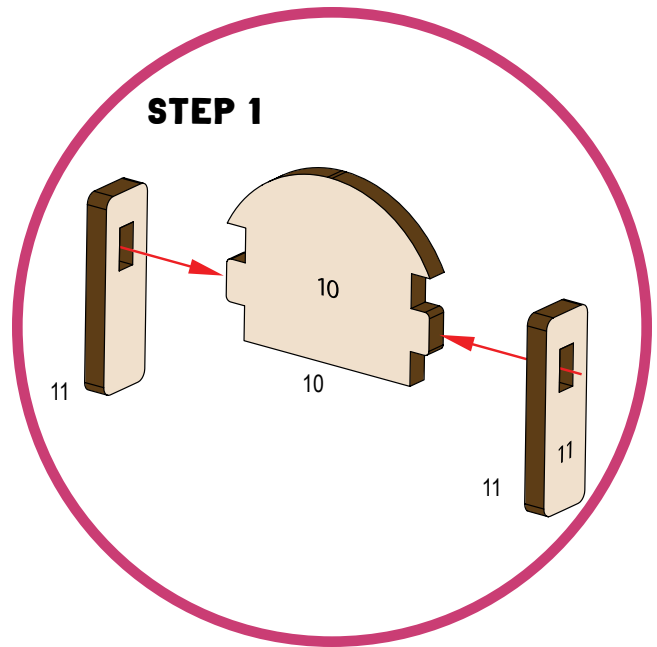
STEP 1

Gather all Parts 10 and 11. Glue the Parts 11 onto either side of the Part 10. Let dry.



STEP 2

Check all your joints and make sure everything moves freely. You are ready to test your ballista!

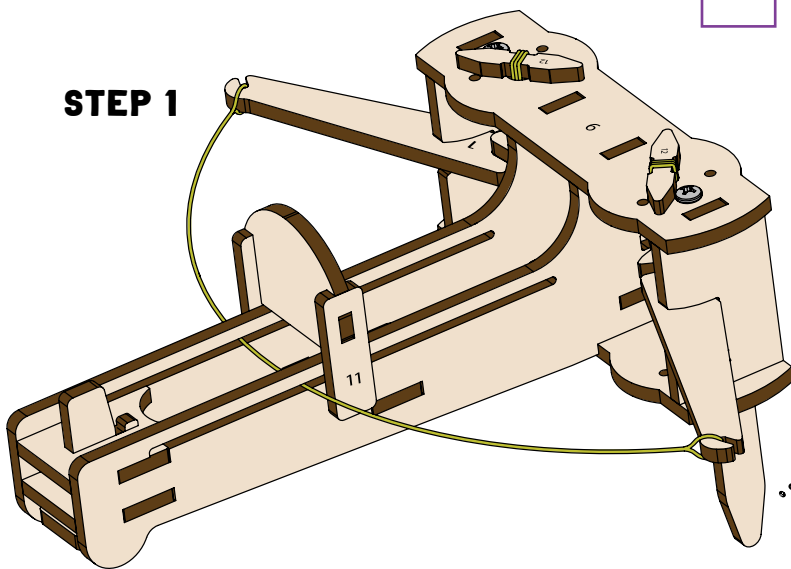


READY, AIM, FIRE!



STEP 1

Carefully, place the ballista where you wish to fire it. Holding onto the ballista at the back end with a finger under the trigger (Part 8), use the device made in the previous section to pull back the string to the trigger. Holding it in place, push up the trigger to secure the string.



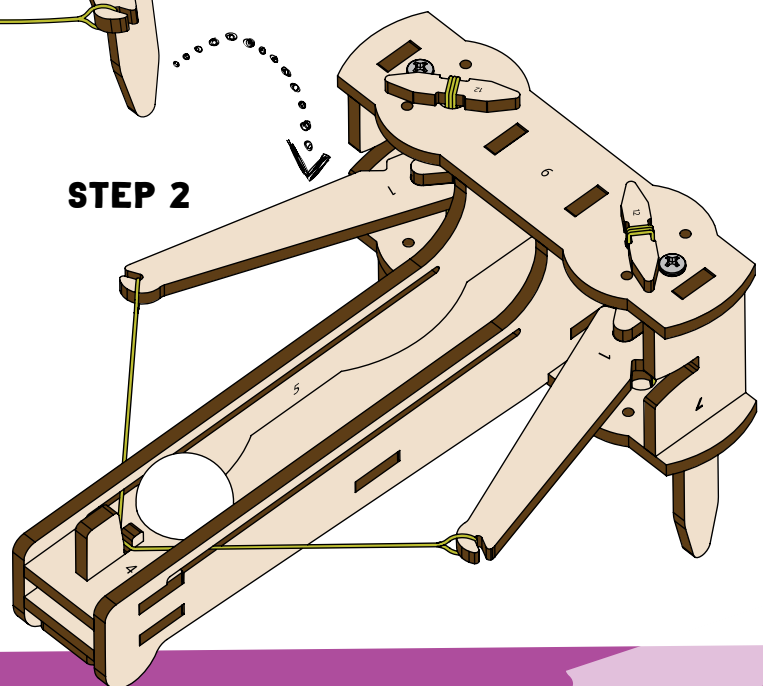
STEP 1

STEP 2



STEP 2

Place a Styrofoam ball in front of the trigger. Push down the trigger, and the ball will fly!

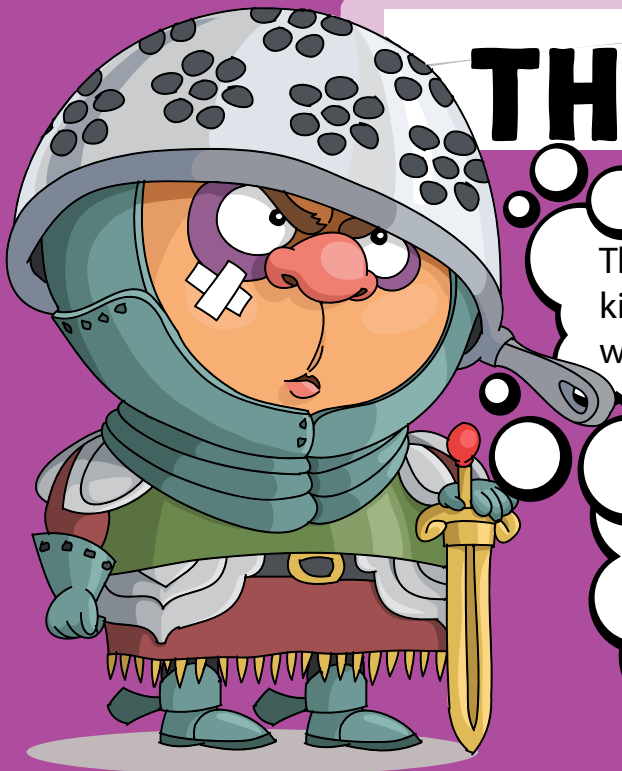




SAFETY

- Anyone operating the Torsion Ballista or who is nearby during its operation should wear safety glasses.
- Never use a sharp object as a projectile.
- Never fire at a living thing.
- Use this device only in the manner discussed and illustrated within this guide. Misuse of this product can cause serious injury.
- Make sure the launch site and flight path are clear of all people prior to launch.

THINK ABOUT IT



Think about the different forms of energy (potential, kinetic, mechanical, and so on). Which ones are used with the Torsion Ballista?

If you were living in the Middle Ages and commanding the attack, how would you use the ballista as part of your assault? How would you defend against it?