Build a Tower Crane: A STEM Challenge!

October 07, 2024 / DIY / STEM Activities / Engaging Engineering Building / Ages 9 - 12 / Stem Tower Crane

Tower
Crane

Have you ever seen a crane? These tall cranes, usually seen on large construction sites, can lift very heavy loads. Want to know how they work? Make this amazing cardboard crane yourself, and you'll learn about the science and engineering principles behind them, as well as how to move and place heavy objects precisely.

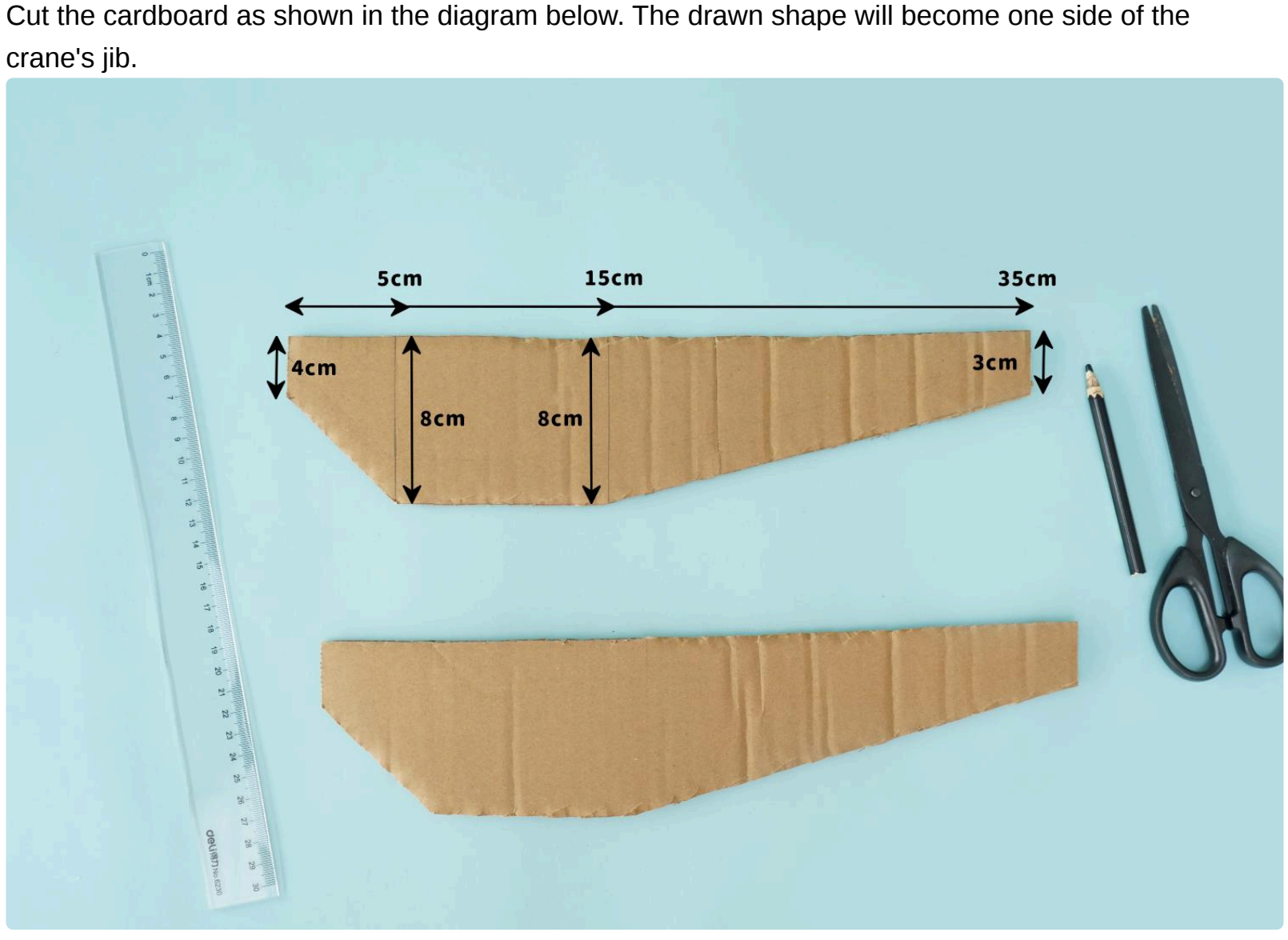
- Age: 9-12
- Time: Over 2 hours
- Mess Level: Messy

Materials Needed:

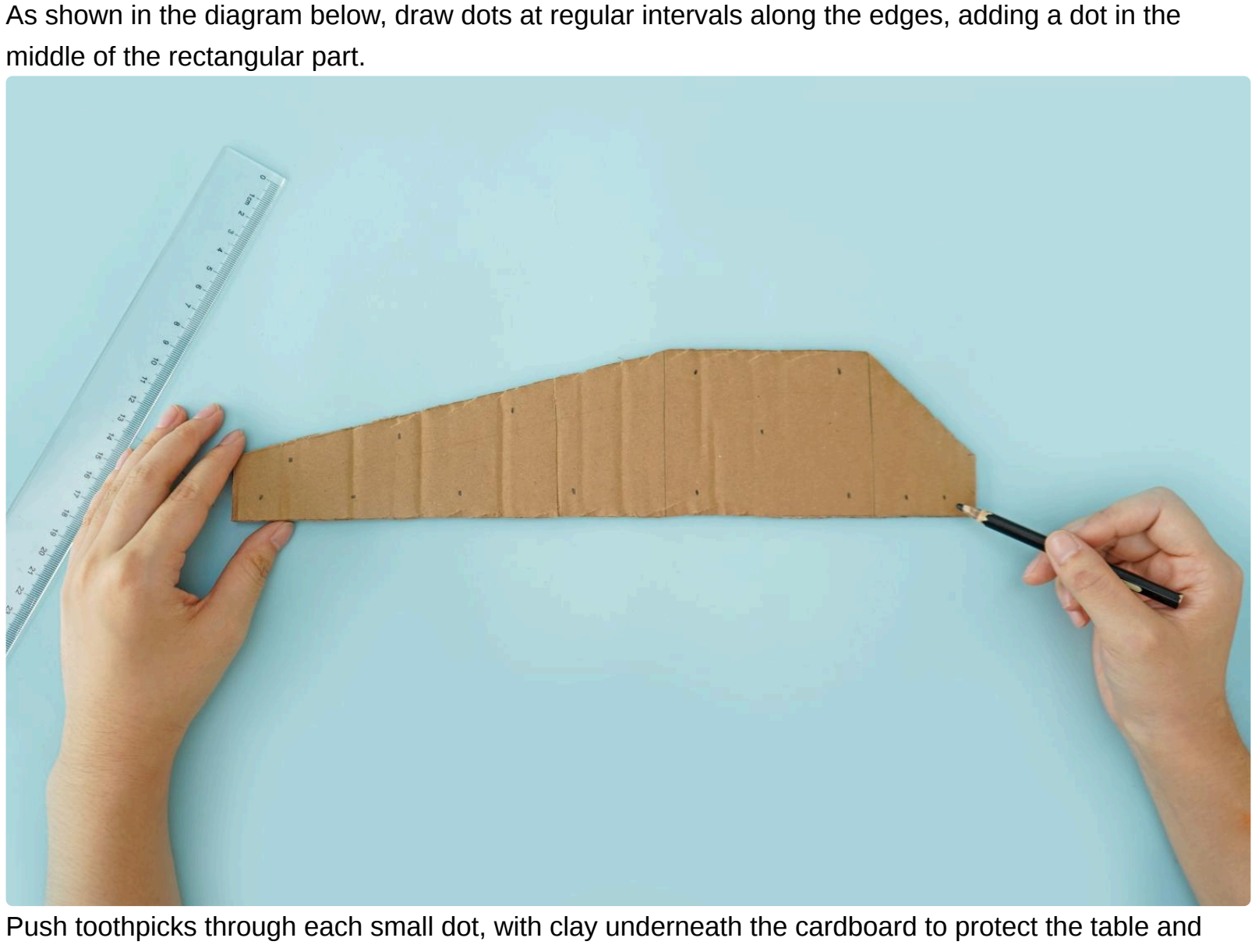
- Two cups
- Small bucket
- Paper tape
- Several small balls
- Plastic bottle
- White glue
- Ruler
- Yarn
- Toothpicks
- Pencil
- Scissors
- Wooden sticks
- Clay
- Acrylic paint
- Paintbrush
- Cardboard

Step-by-Step Instructions:

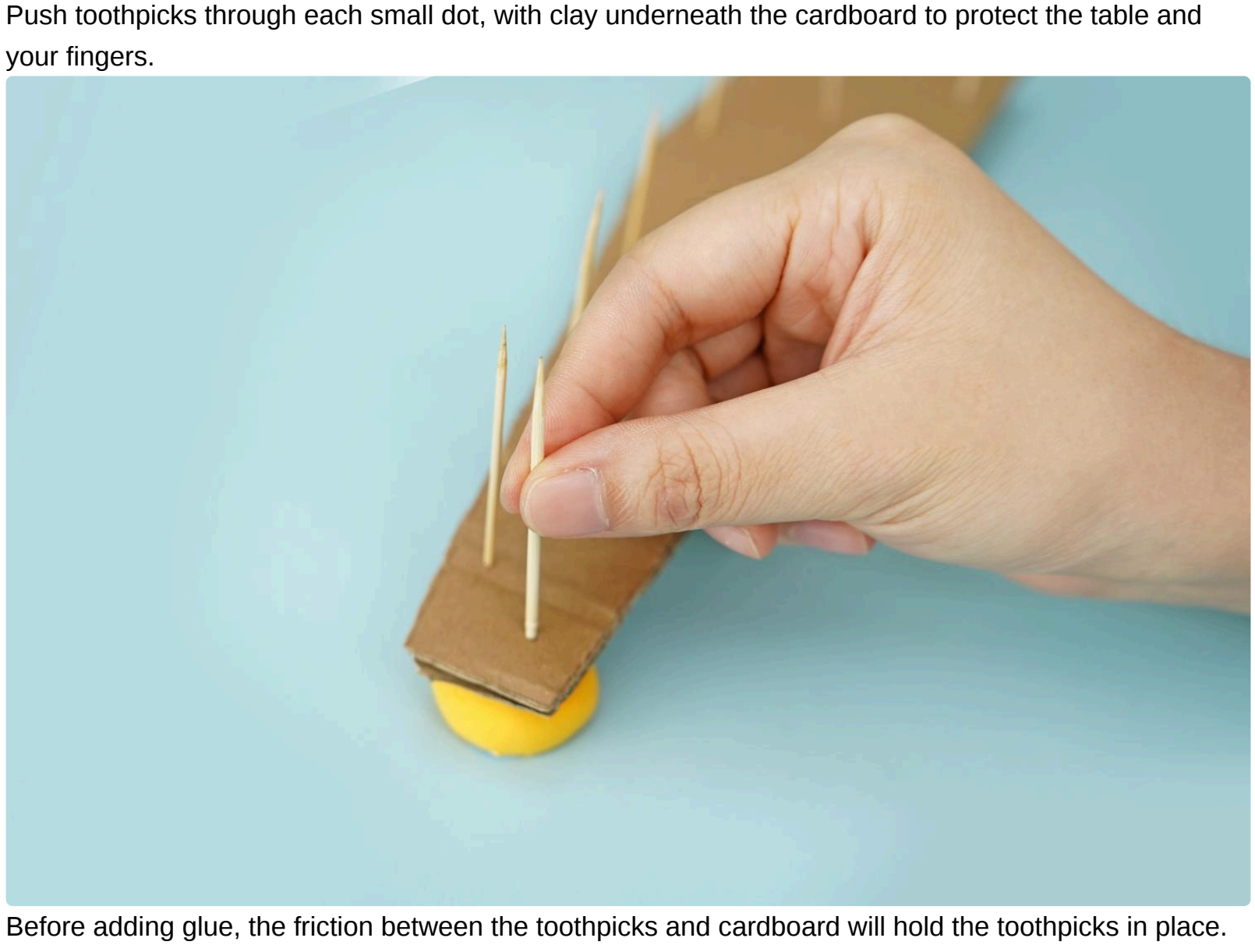
1. Cut the cardboard as shown in the diagram below. The drawn shape will become one side of the crane's jib.



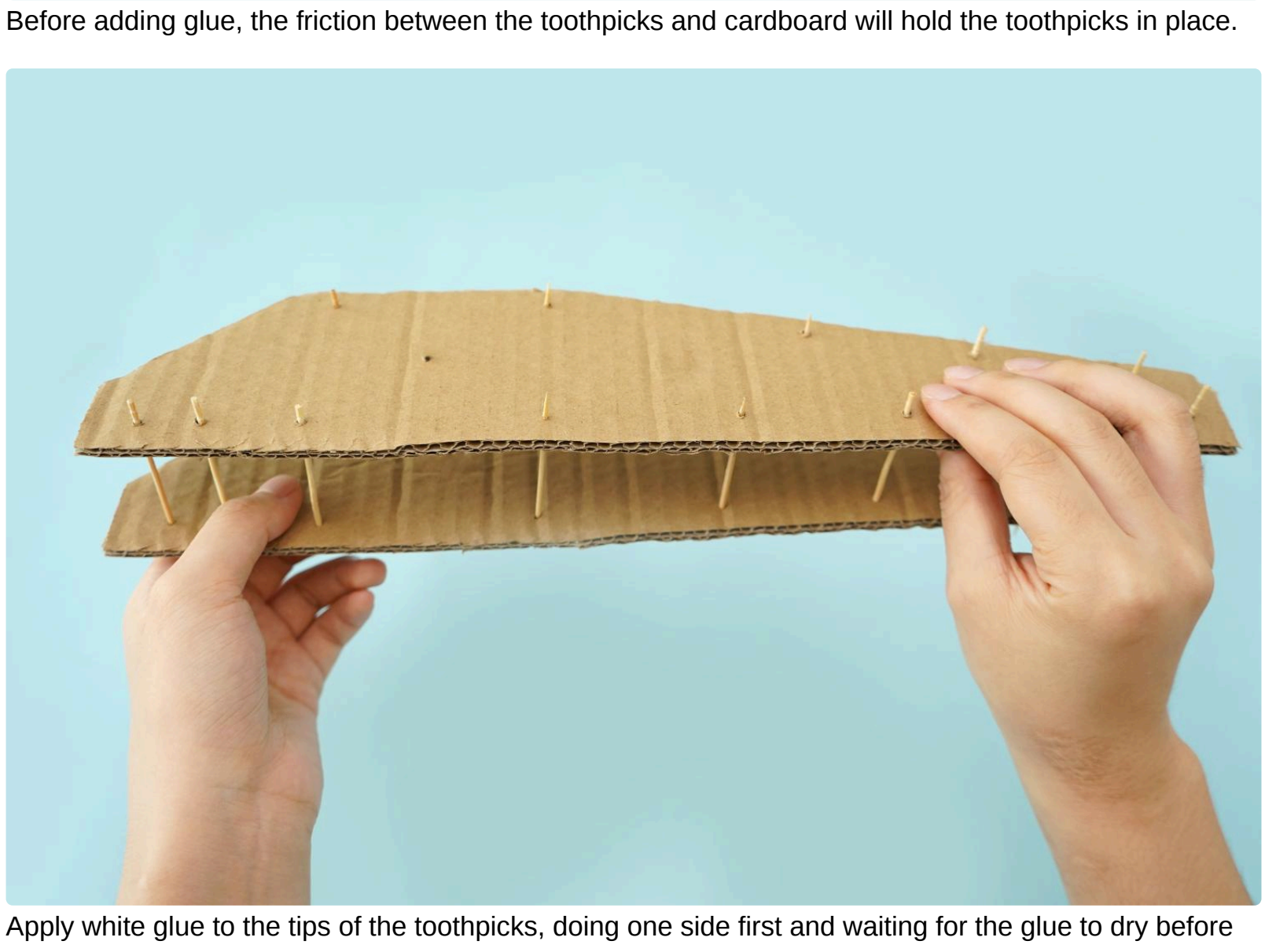
2. As shown in the diagram below, draw dots at regular intervals along the edges, adding a dot in the middle of the rectangular part.



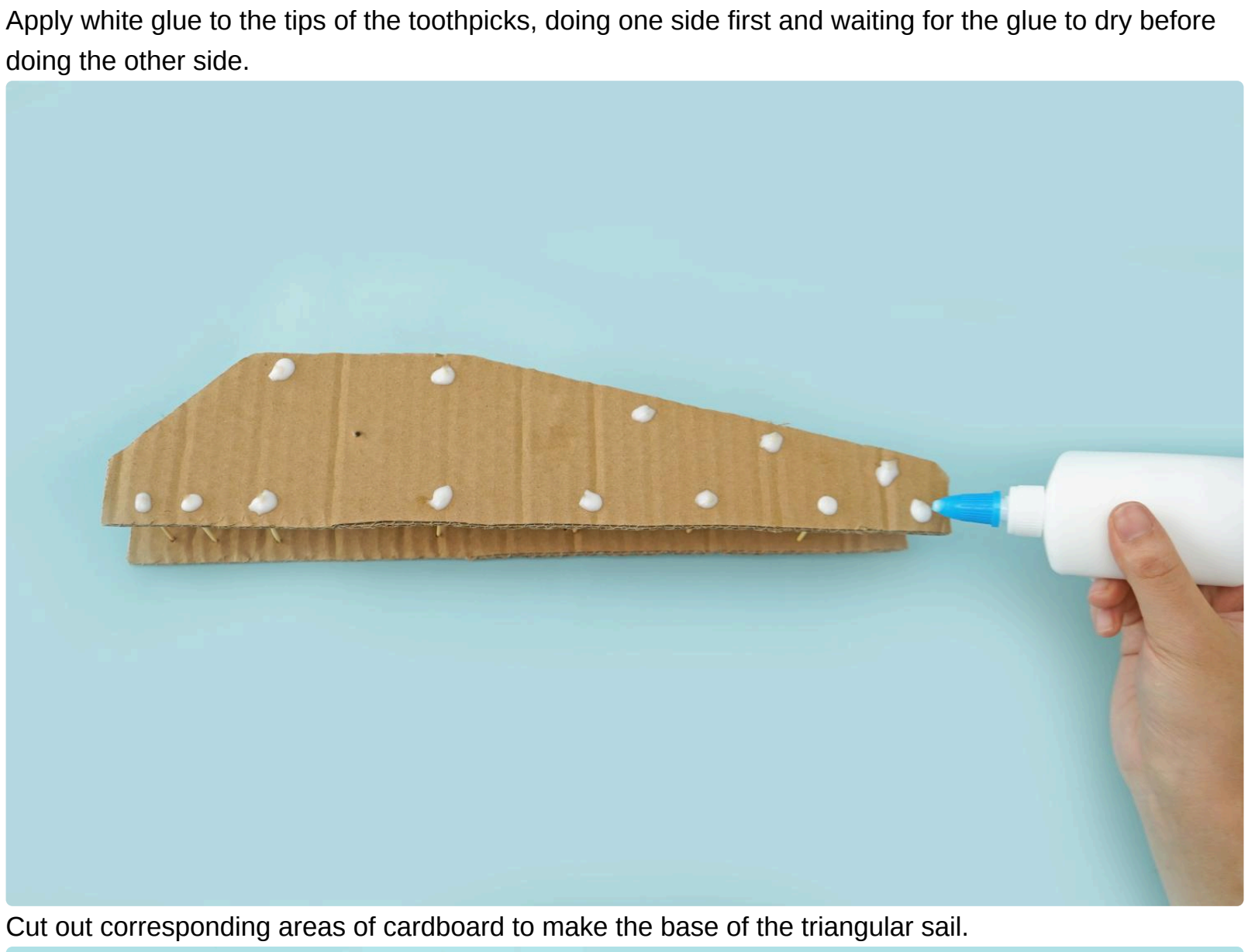
3. Push toothpicks through each small dot, with clay underneath the cardboard to protect the table and your fingers.



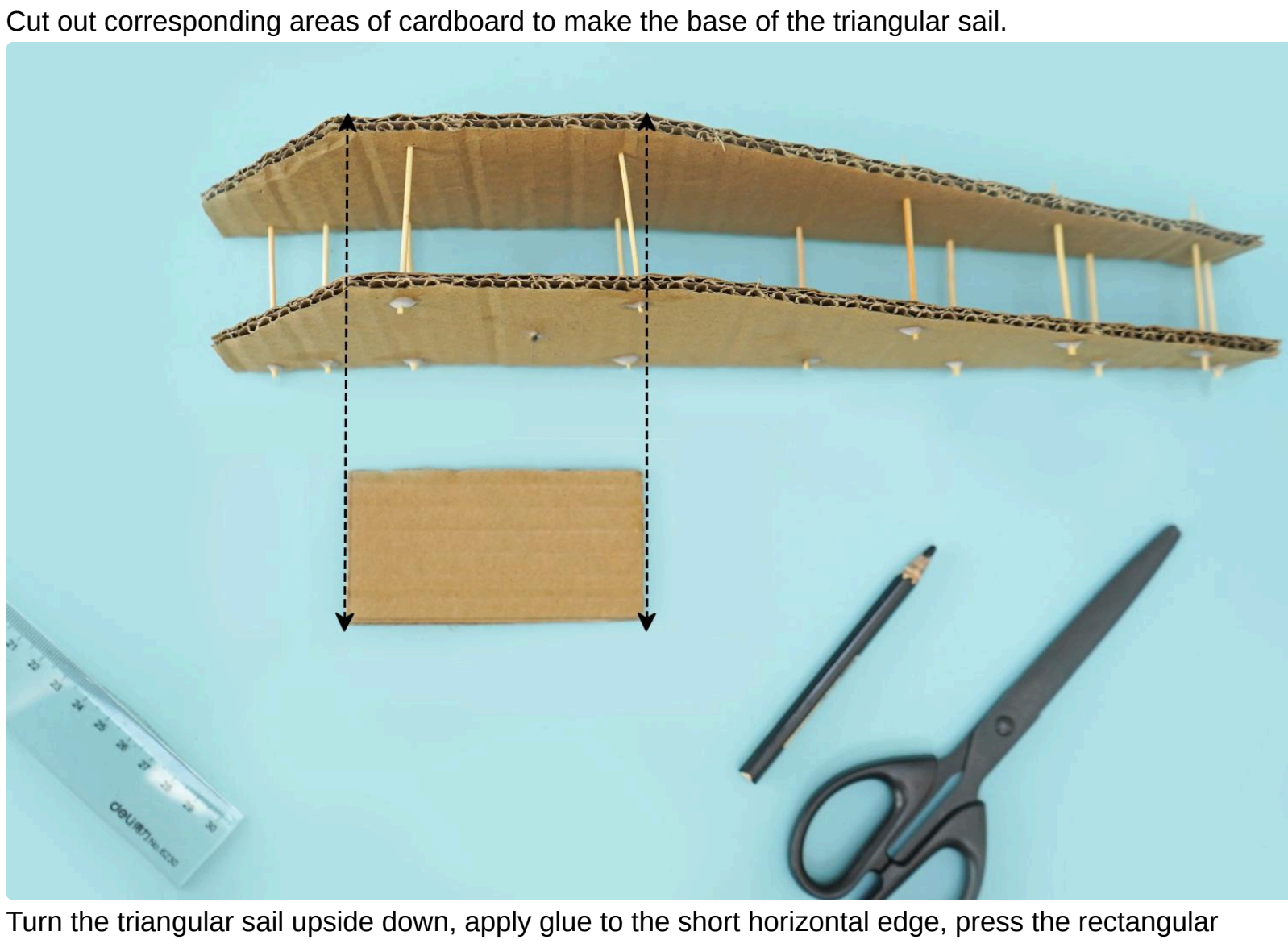
Before adding glue, the friction between the toothpicks and cardboard will hold the toothpicks in place.



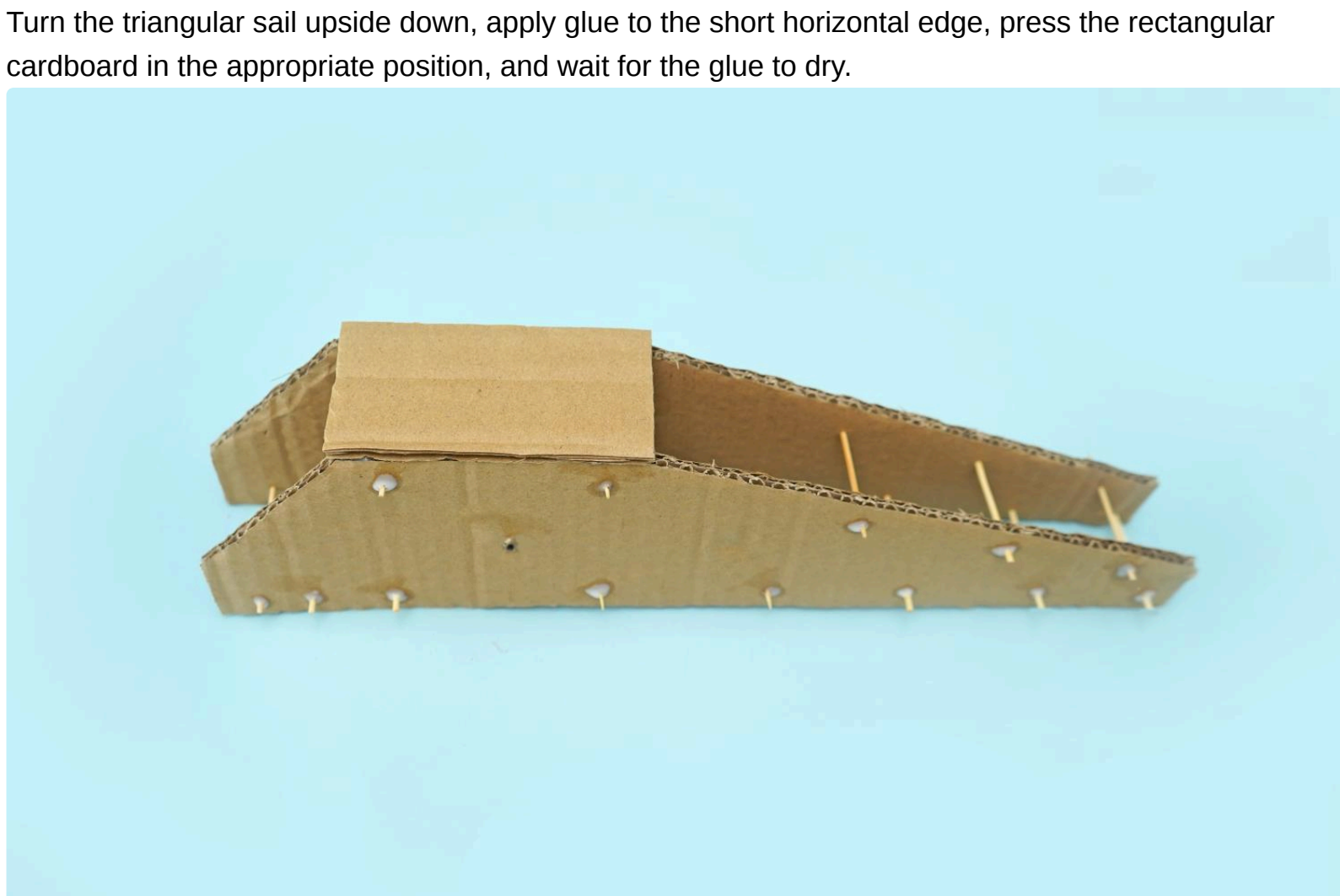
4. Apply white glue to the tips of the toothpicks, doing one side first and waiting for the glue to dry before doing the other side.



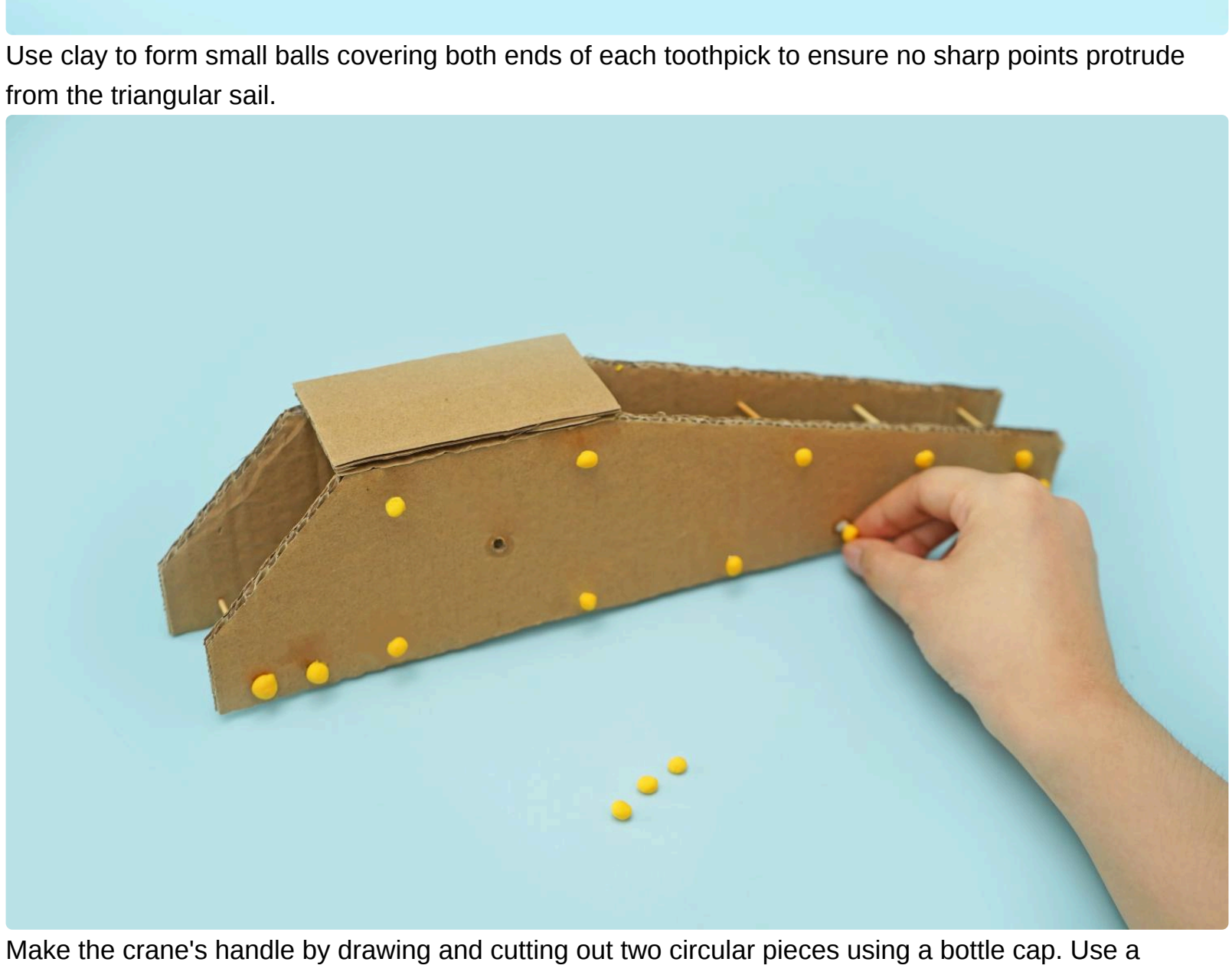
5. Cut out corresponding areas of cardboard to make the base of the triangular sail.



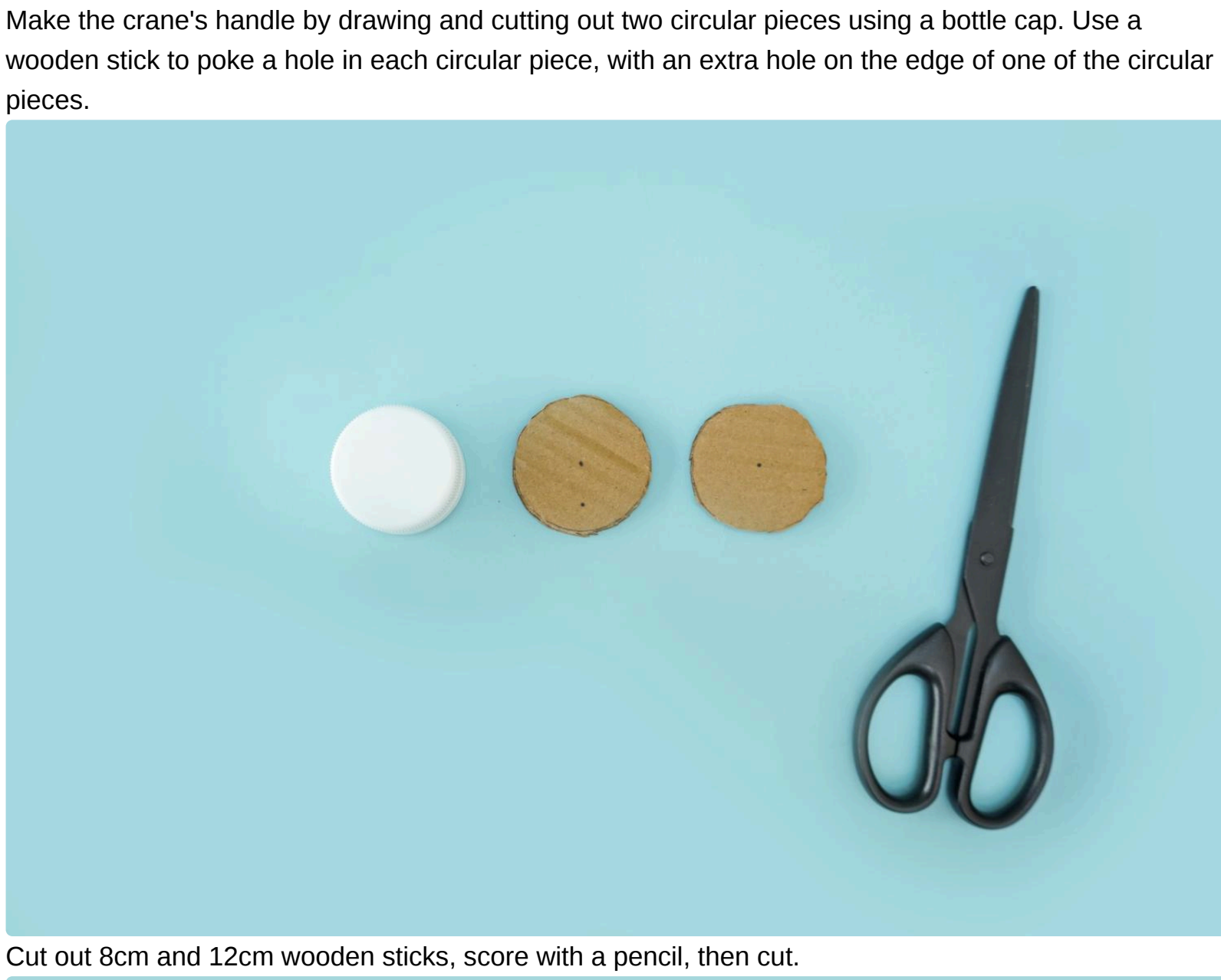
6. Turn the triangular sail upside down, apply glue to the short horizontal edge, press the rectangular cardboard in the appropriate position, and wait for the glue to dry.



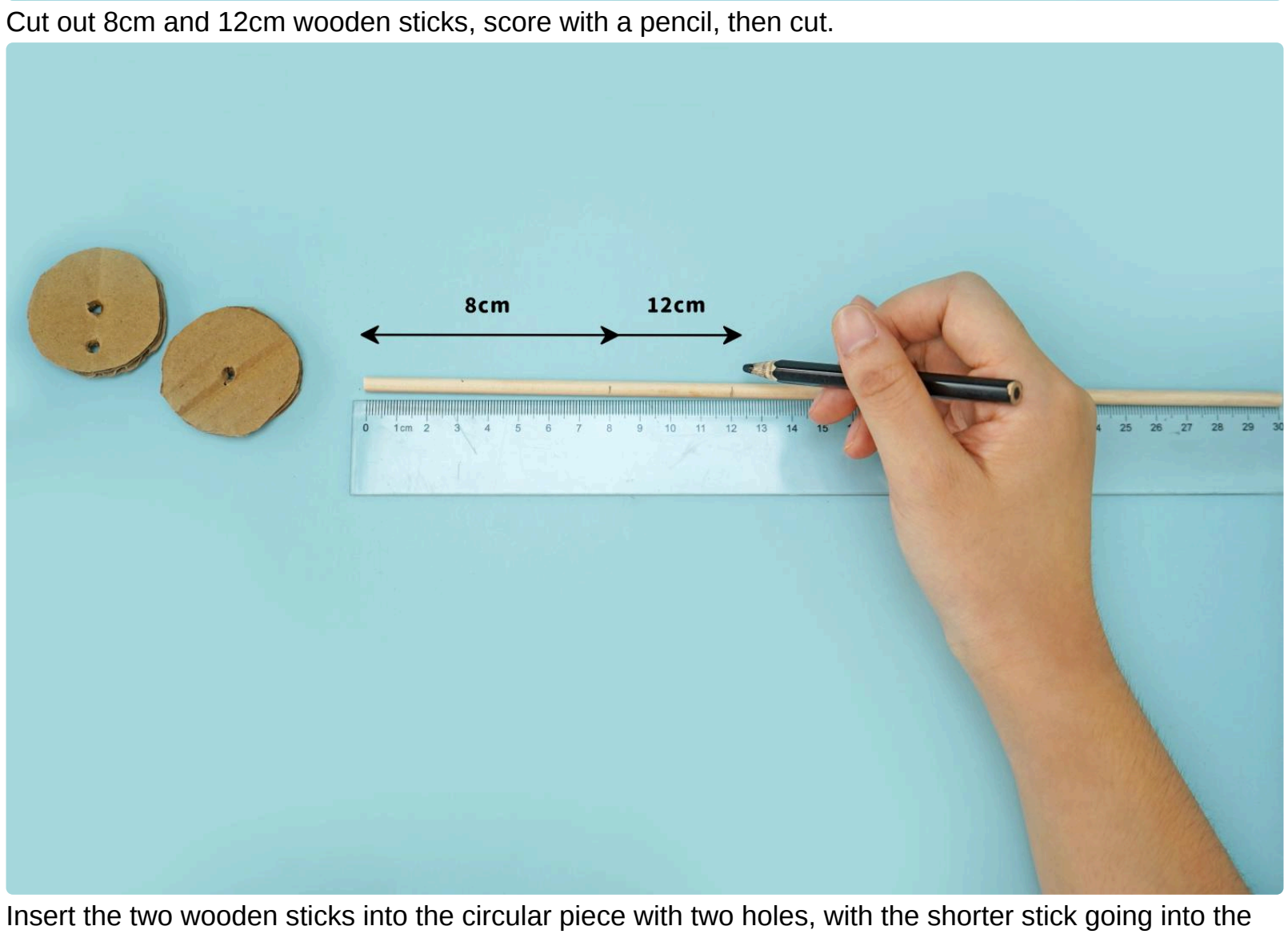
7. Use clay to form small balls covering both ends of each toothpick to ensure no sharp points protrude from the triangular sail.



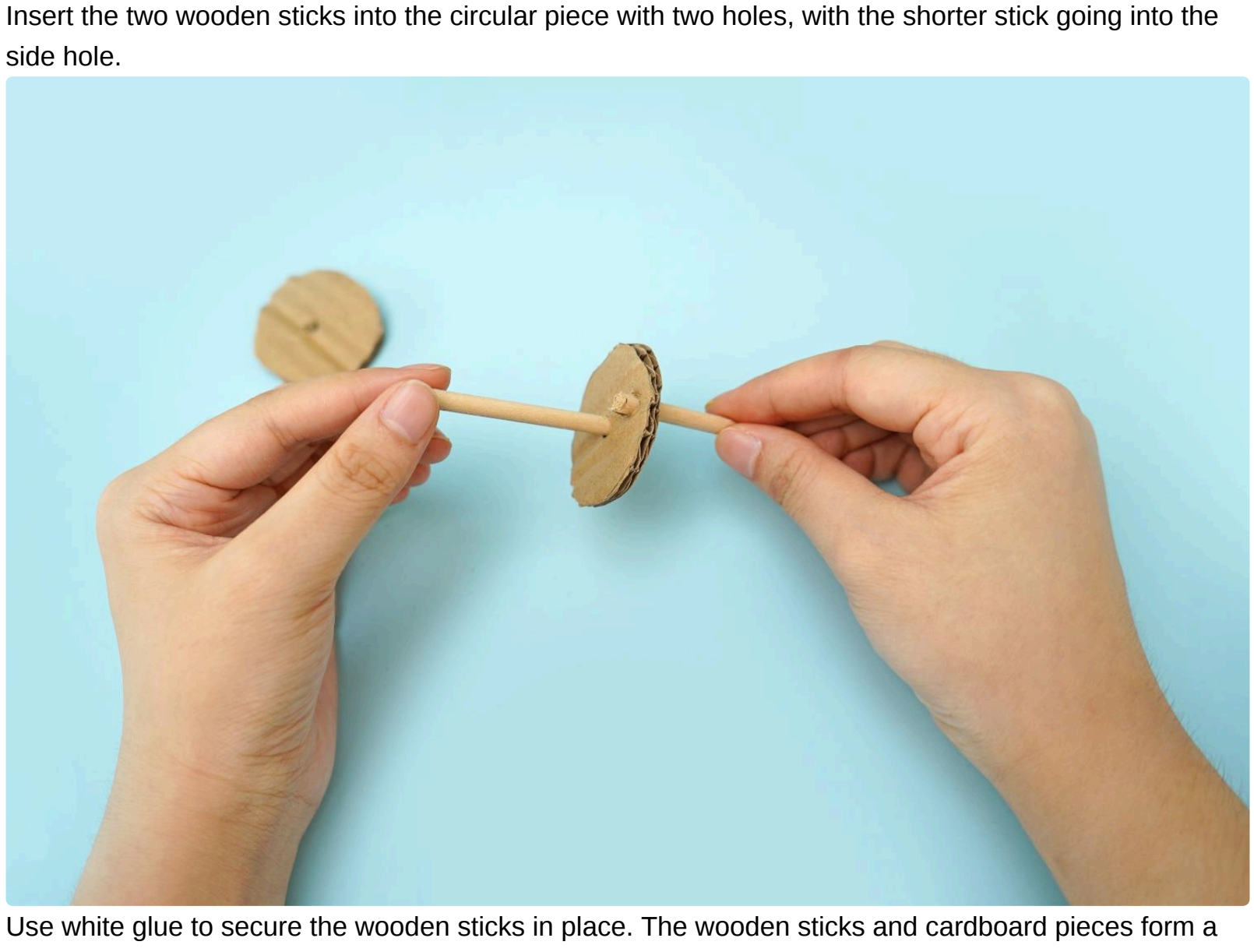
8. Make the crane's handle by drawing and cutting out two circular pieces using a bottle cap. Use a wooden stick to poke a hole in each circular piece, with an extra hole on the edge of one of the circular pieces.



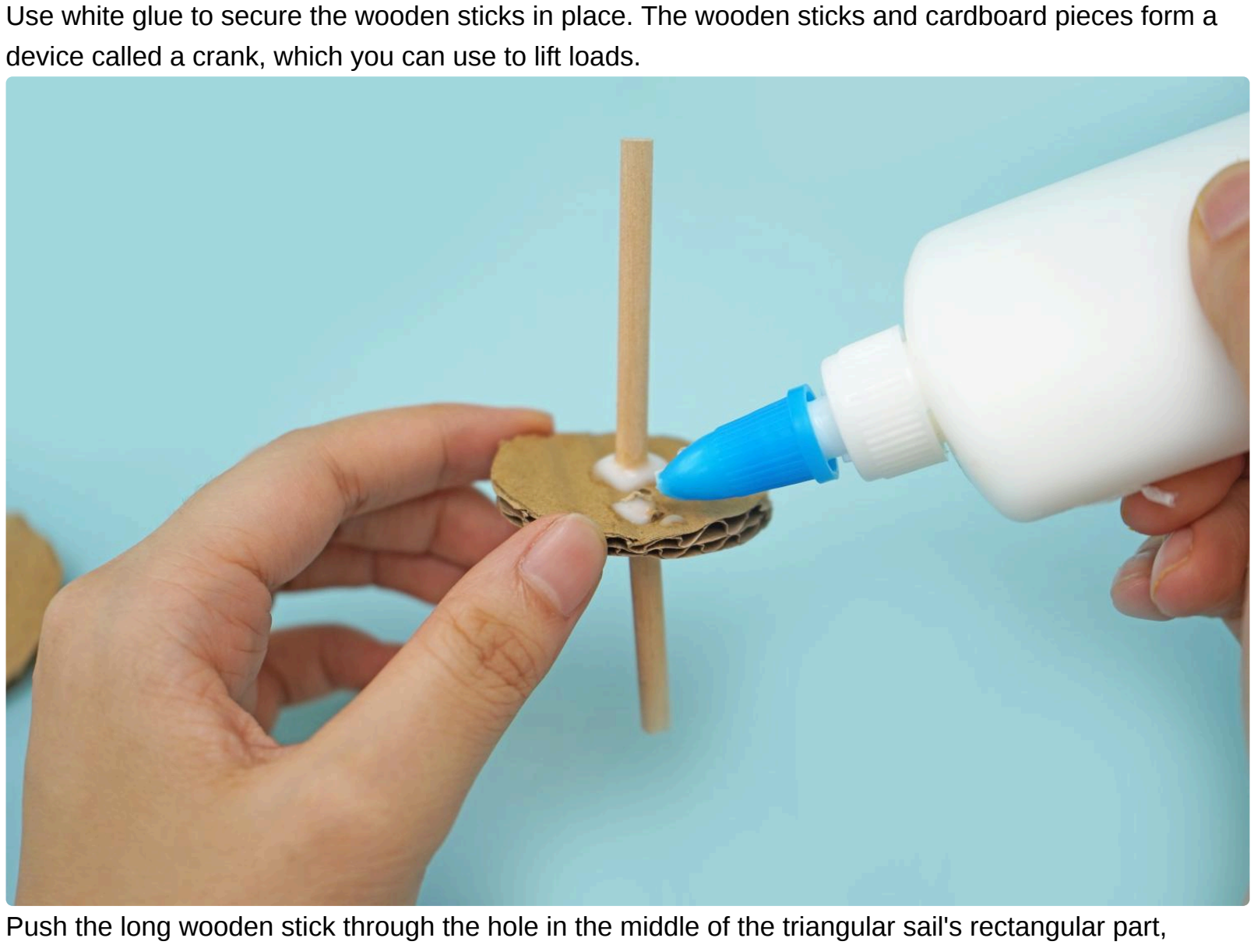
9. Cut out 8cm and 12cm wooden sticks, score with a pencil, then cut.



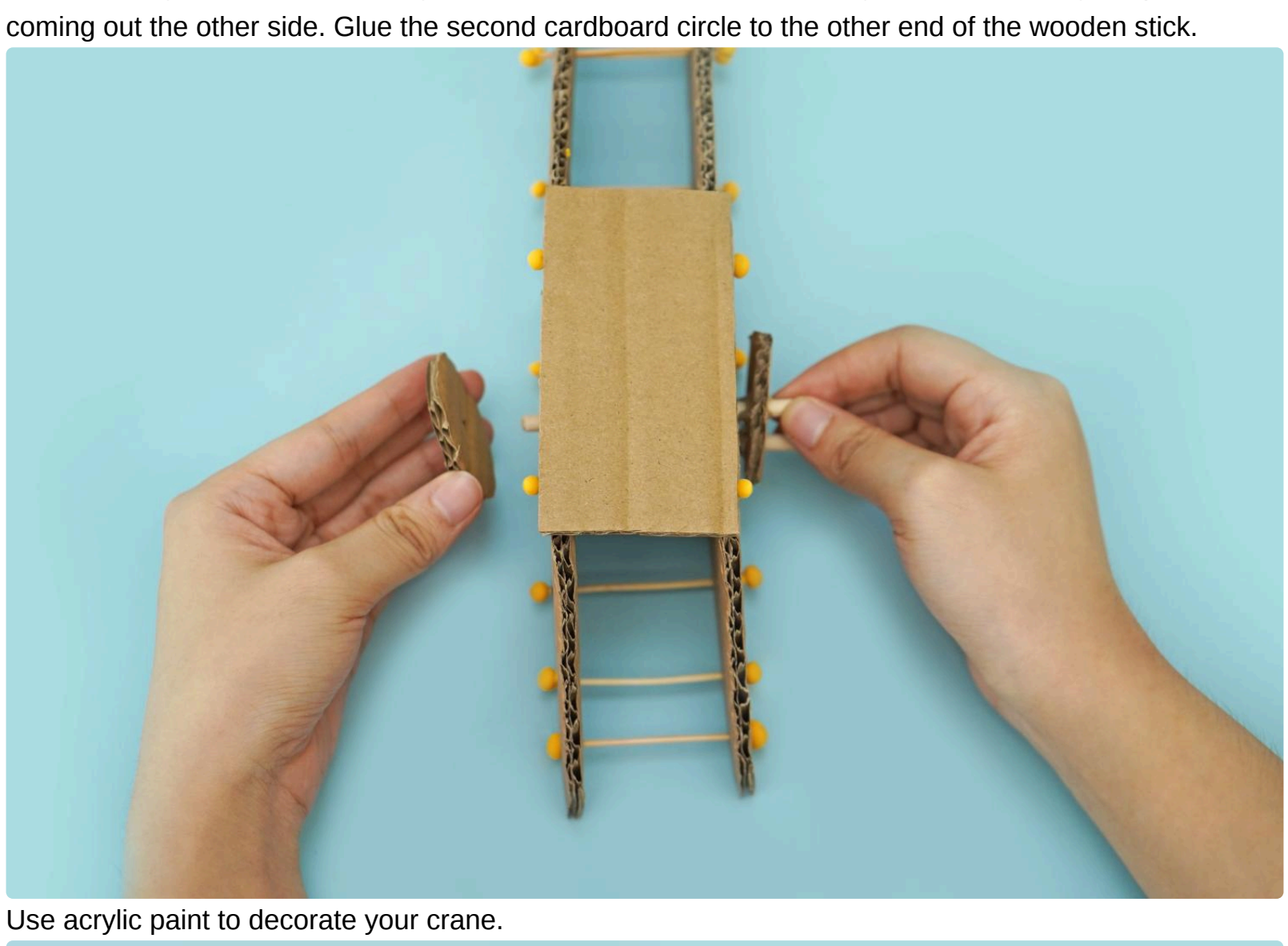
10. Insert the two wooden sticks into the circular piece with two holes, with the shorter stick going into the side hole.



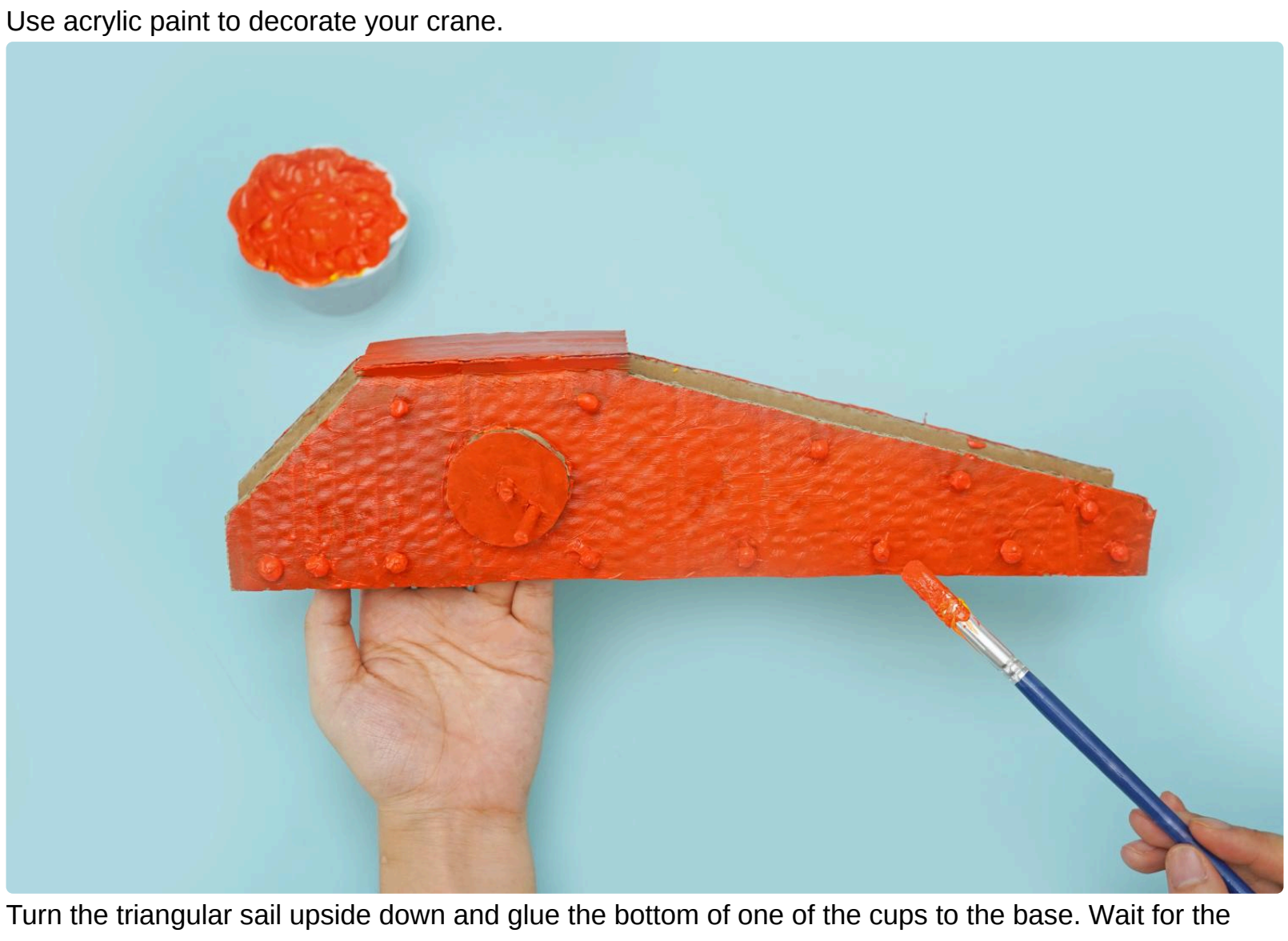
11. Use white glue to secure the wooden sticks in place. The wooden sticks and cardboard pieces form a device called a crank, which you can use to lift loads.



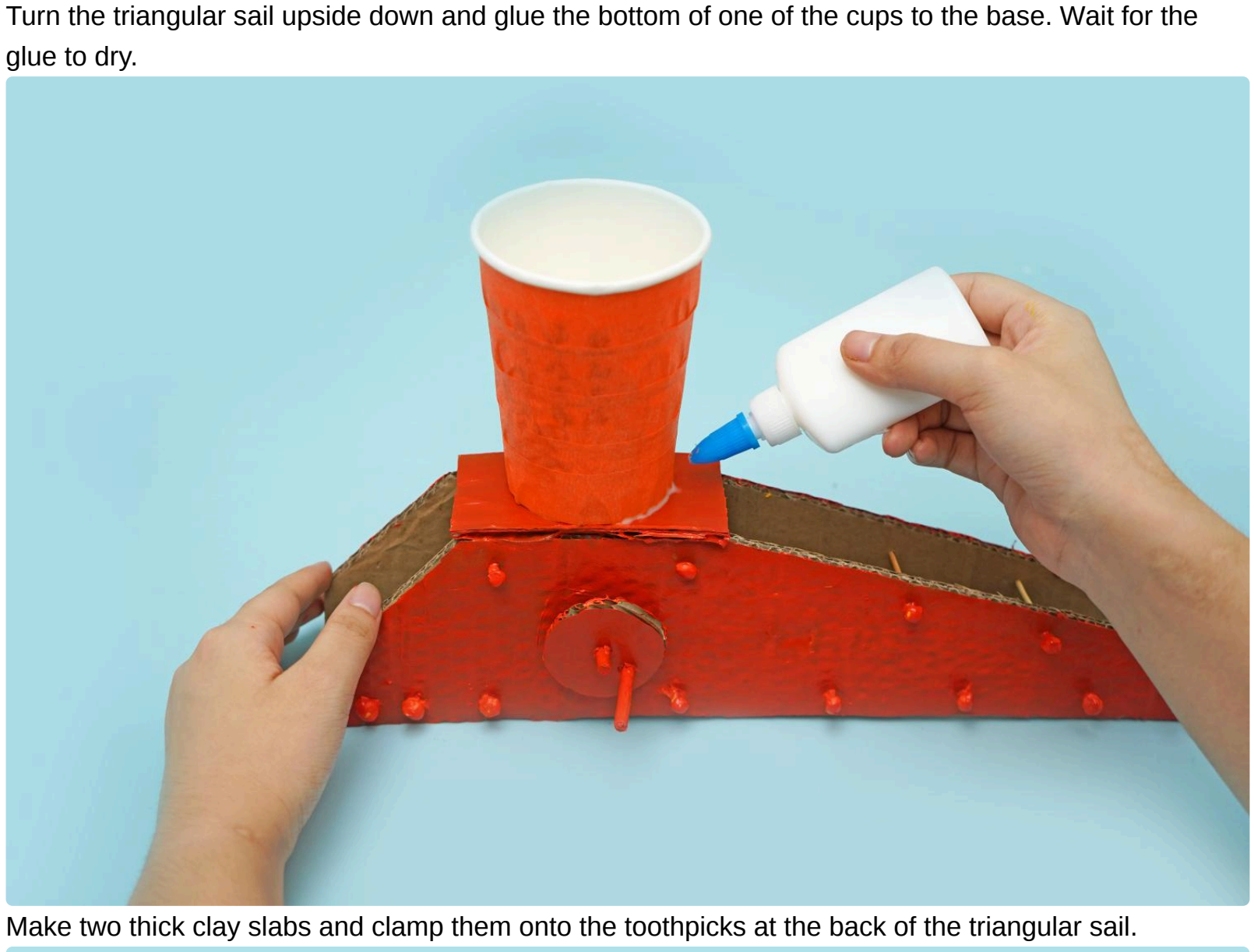
12. Push the long wooden stick through the hole in the middle of the triangular sail's rectangular part, coming out the other side. Glue the second cardboard circle to the other end of the wooden stick.



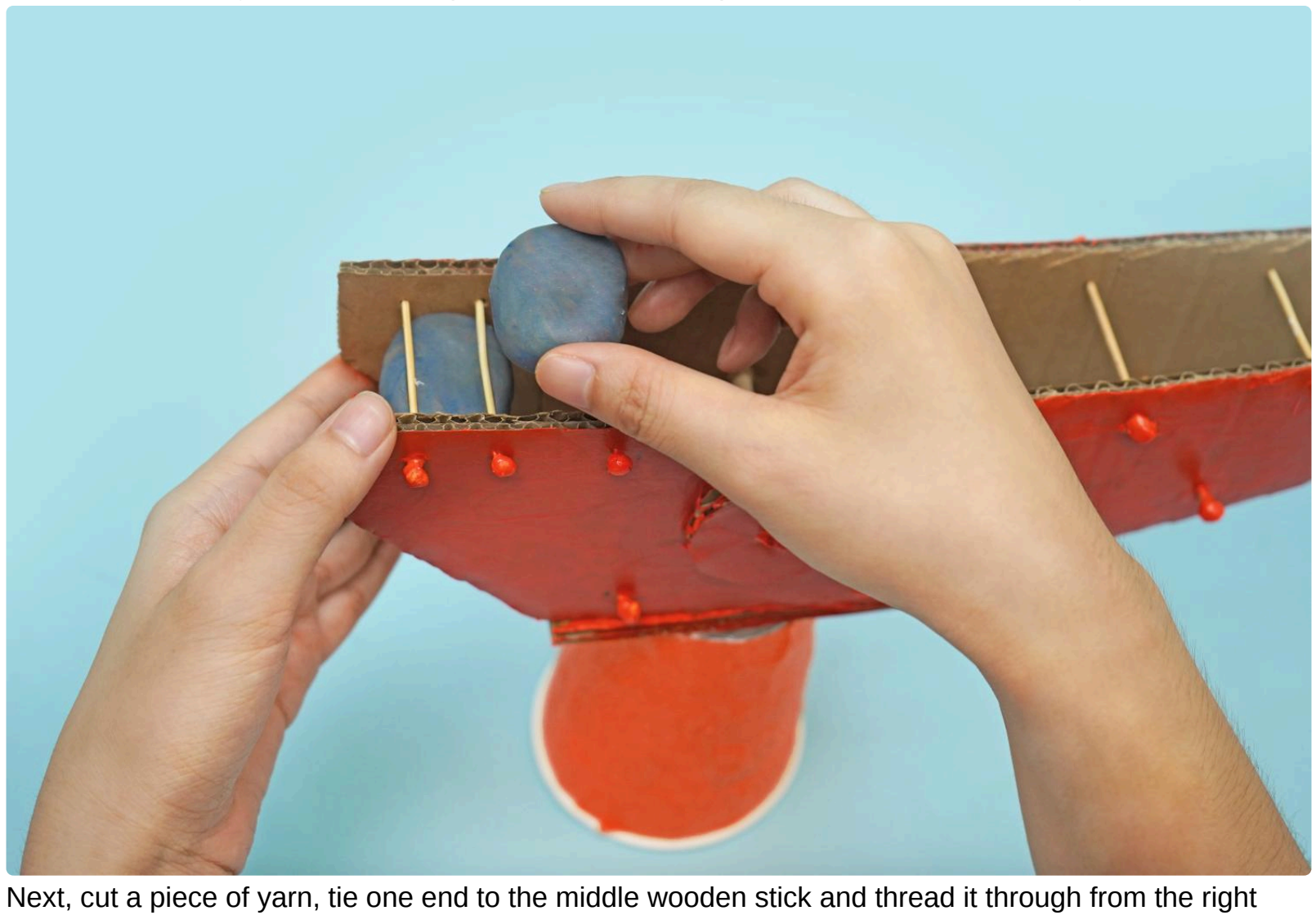
13. Use acrylic paint to decorate your crane.



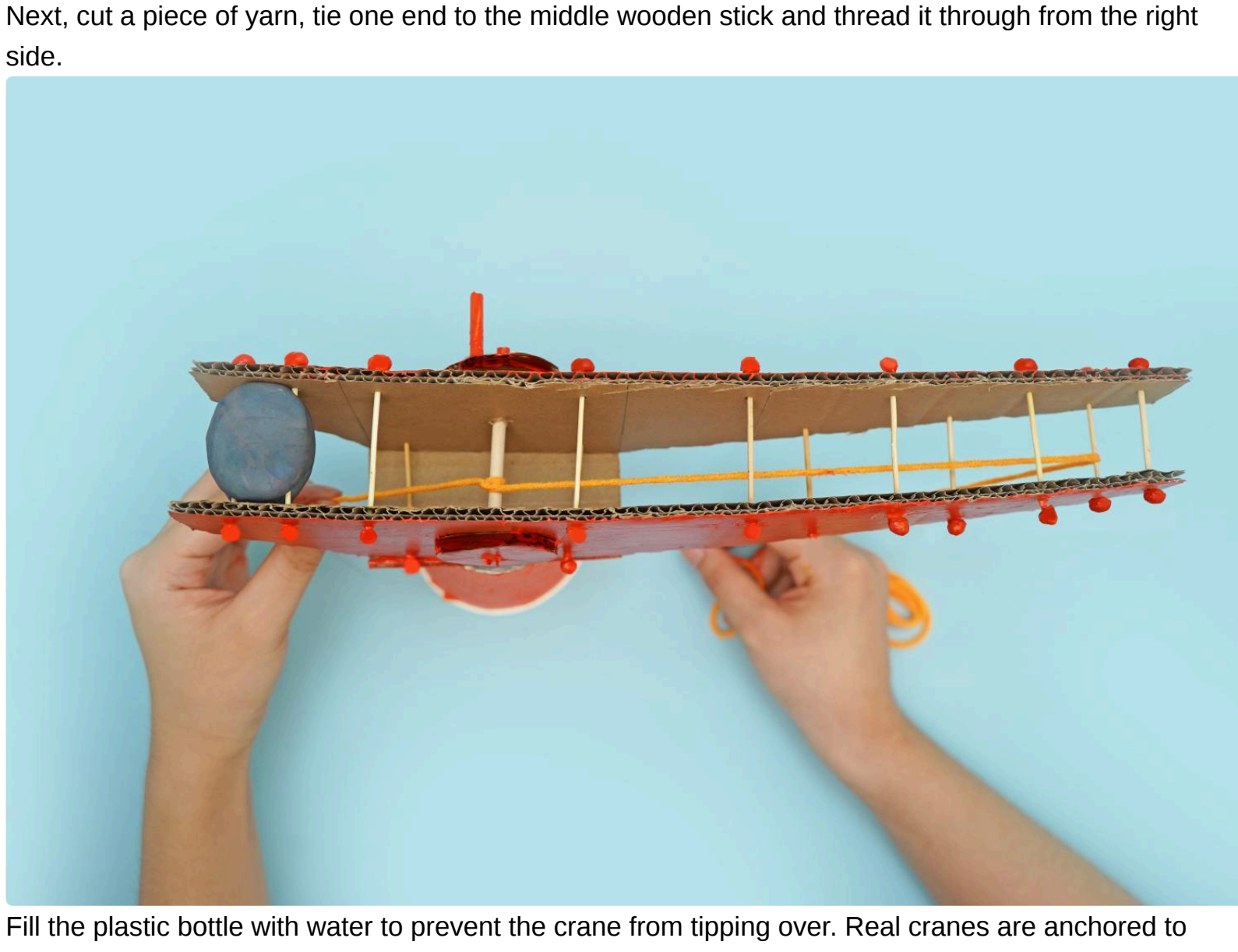
14. Turn the triangular sail upside down and glue the bottom of one of the cups to the base. Wait for the glue to dry.



15. Make two thick clay slabs and clamp them onto the toothpicks at the back of the triangular sail.



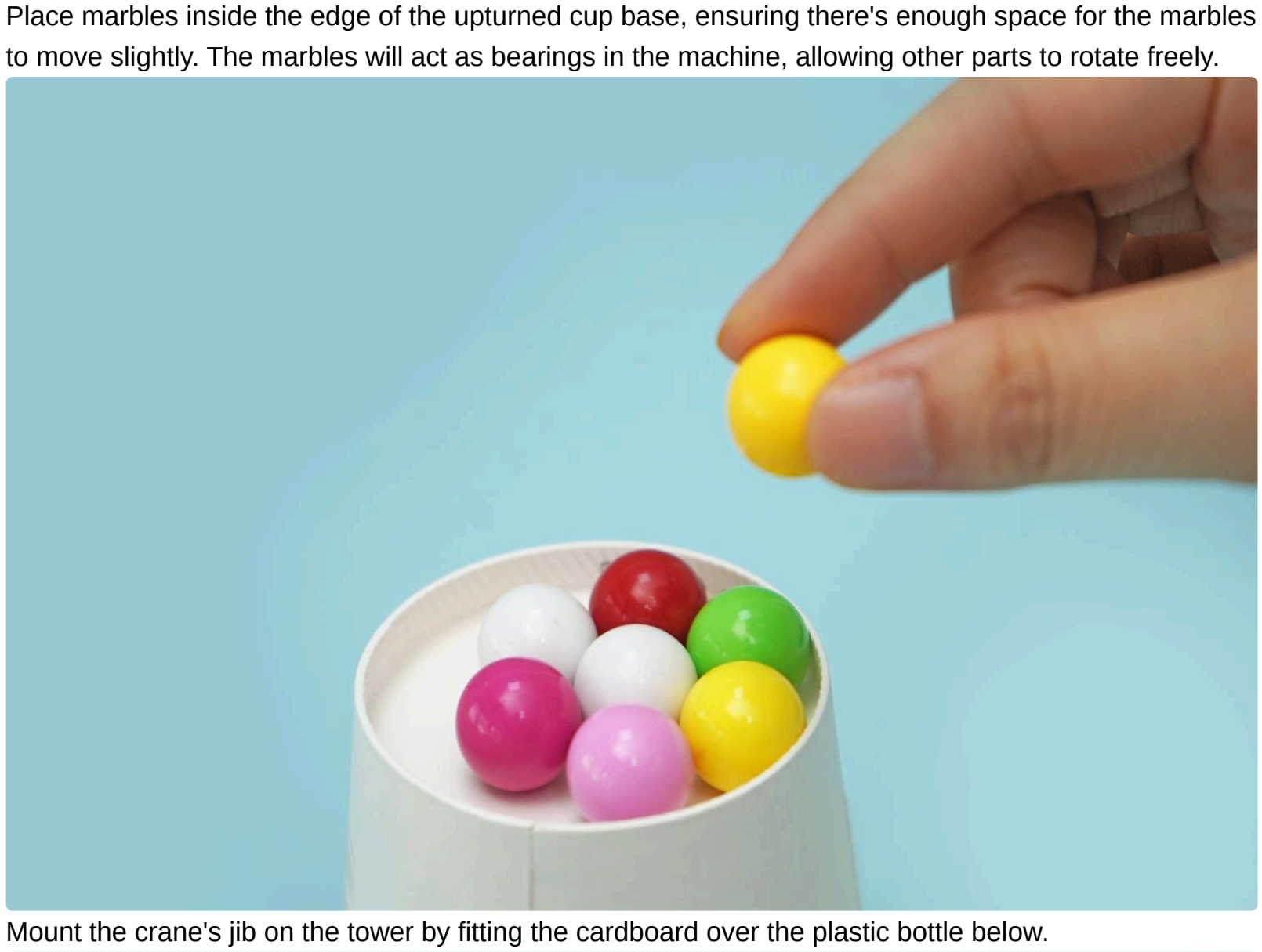
16. Next, cut a piece of yarn, tie one end to the middle wooden stick and thread it through from the right side.



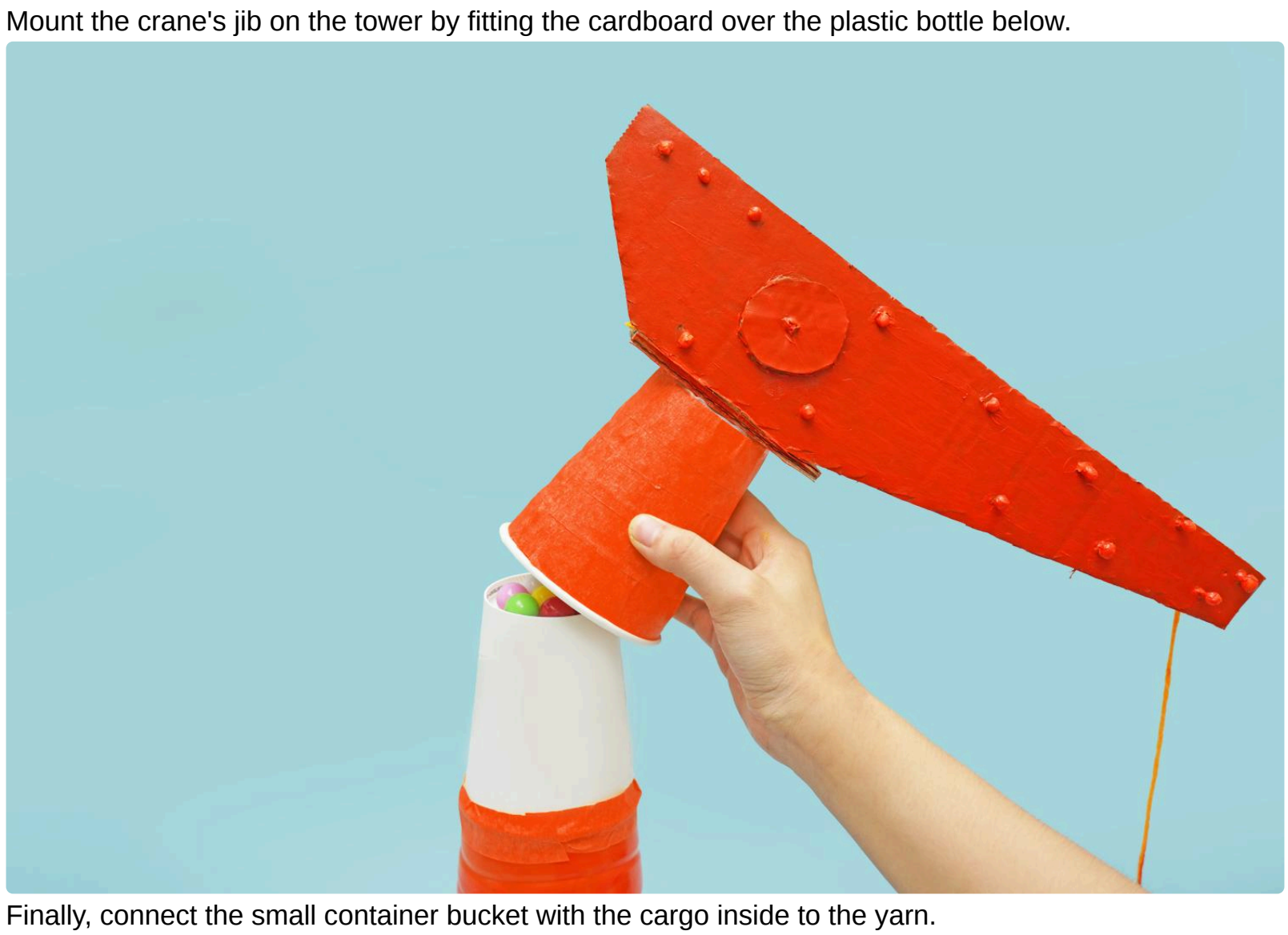
17. Fill the plastic bottle with water to prevent the crane from tipping over. Real cranes are anchored to heavy concrete bases for stability; your model's heavy base does the same job.

18. Use paper tape to secure the second cup to the plastic bottle.

19. Place marbles inside the edge of the upturned cup base, ensuring there's enough space for the marbles to move slightly. The marbles will act as bearings in the machine, allowing other parts to rotate freely.

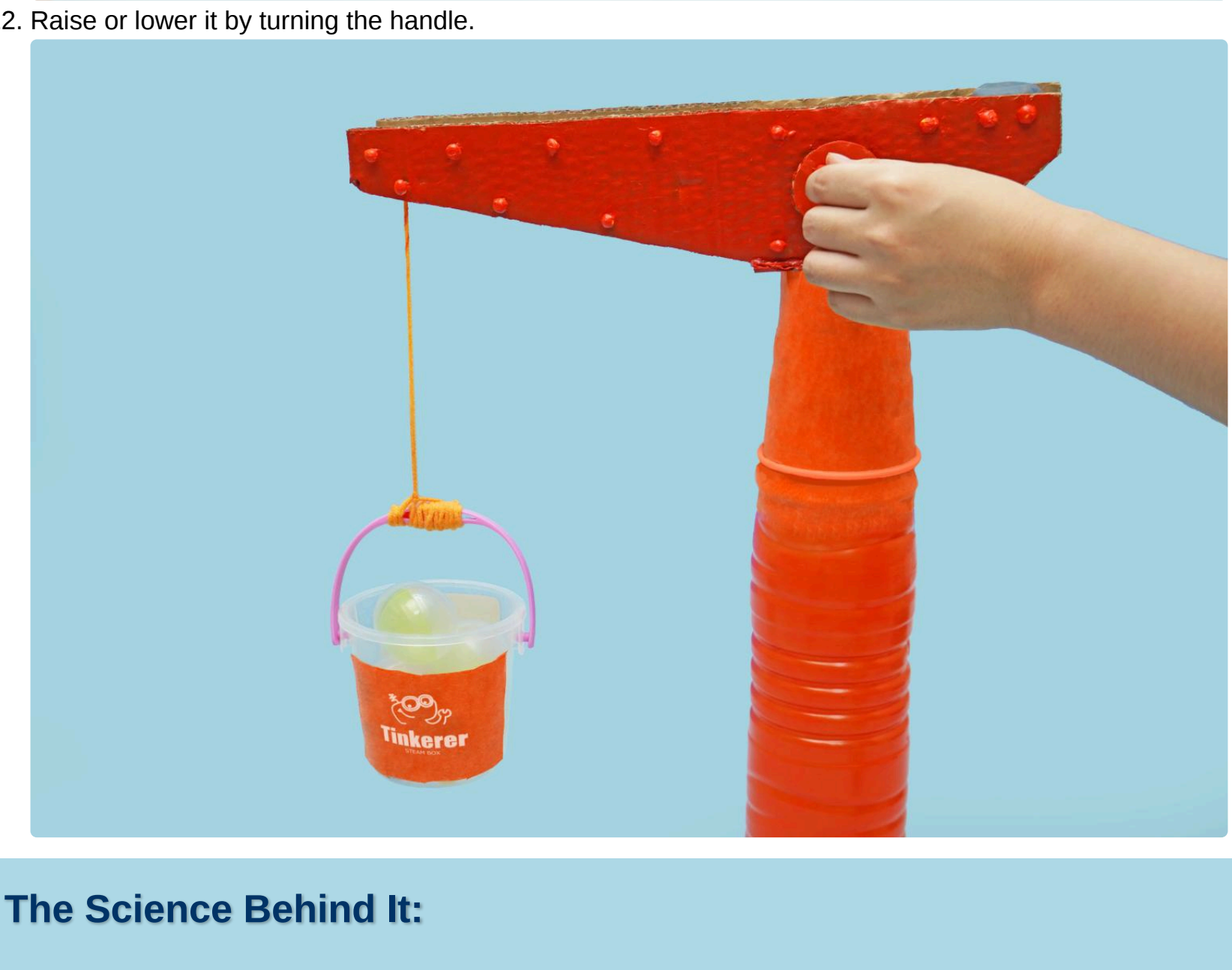


20. Mount the crane's jib on the tower by fitting the cardboard over the plastic bottle below.



21. Finally, connect the small container bucket with the cargo inside to the yarn.

22. Raise or lower it by turning the handle.



The Science Behind It:

Tower cranes can lift enormous loads without toppling because they can control torque. Torque is the rotational force produced by the crane's jib, and its magnitude is related to the position and weight of the load. The further the load is from the tower, the greater the torque, because torque equals the load weight multiplied by the distance of the load from the tower. To balance these torques, the tower crane's ground anchoring system (such as counterweights) counteracts these moments, ensuring the crane's stability. When lifting larger loads, the load is kept close to the tower, while smaller loads can be lifted at greater distances.

Test how much weight your crane can lift without tipping over. Try adjusting the distance of the rope from the tower and see how it affects the weight the crane can lift. What happens if you adjust the crank handle wheel, making it larger and allowing it to move in a bigger circle? See what changes occur when you increase or decrease the weight of the counterbalance.