Make Your Own Exhibit

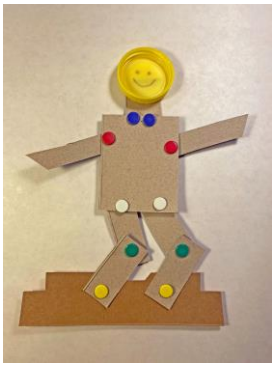
From the Simple Machines Gallery: Linkages

At Discovery Museum, we like to explore movement—the movement of air, of water, of our own bodies, and the movement of simple mechanisms found in our everyday lives. In our Simple Machines Gallery, we have exhibits that use mechanisms called **Linkages** to move. We can make our own moving creations, simple and complex, using homemade linkages. Let's get started!

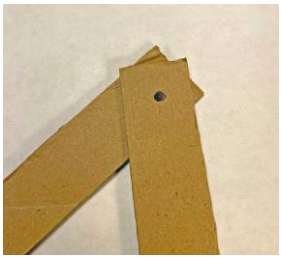
Supplies

Be sure to ask an adult for help as you gather your supplies to create the exhibit!

- Cardboard from any type of box (shipping box, cereal box) or another stiff paper material
- Corrugated cardboard to use as fasteners (see photo)
- Scissors
- Tape
- Writing tool to make dots
- Something that can poke holes in your material (scissors, small screwdriver, pin, end of a paperclip)
- Optional: tacks or brad/paper fasteners to more easily connect pieces of cardboard together. Once put together, be sure to protect yourself from any sharp points in your linkages by wrapping them in tape or sticking a protective cap over them (see photos).



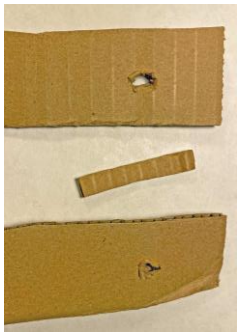
Exploration



- Cut some strips of your material.
- Overlap the ends of two strips—your links—and make a dot on the top link where you would like to poke a hole.
- **With help from your adult,** poke a hole through your top link where you put your dot.
- Return your top link, now with a hole—called a node—so that it's lying on top of your bottom link.
- Arrange the two links in the position you want to connect them, and mark a dot on the bottom link to mark the spot for the next node. You can do this by

marking the bottom link through the small hole of the top link, or you can lift the top link up if your hole is too small to mark through.
- **With help from your adult**, poke a hole through your bottom link where you put your dot.
- Connect your two links together using the cardboard fastener shown below, or another type of fastener (see photos below).

What do you notice about the movement of your links?




Your two links together now make a *linkage*—an assembly of two or more links—and this particular linkage is called a *hinged joint*.

After making a few hinged joints using our suggested steps, you can develop a method that works best for you as you align your links and locate and make the nodes to join them together. As the chief engineer of this project, you can design your own safe style for creating your linkages.

Things to try

- Try adding a third link to your hinged joint.

  What do you notice about the movements of your linkage?
- Move the location of the nodes on your links.

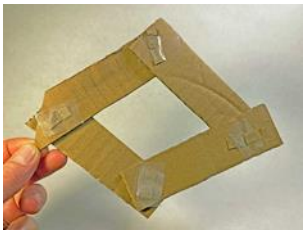
  Does anything change in the linkage motion if links are connected in places other than at their ends?
- Use both short and long links.

  Does linkage length change anything about their movements?
- Put more than two nodes in a link and connect to it.

  What do you notice?
- Make small holes and big holes to connect your links together.

  What do you notice about the movement of the individual links and your linkage as a whole?
- Make a closed shape (see photo).

  What do you notice?



If you make a triangle, what happens if you undo it and add a fourth link? A fifth link? Do you notice anything different about the movement of your shape as you add more links?

Get creative!

Remember, experimenting is about trying new things, observing what happens, and then trying more new things. Not all of the supplies or designs you try will make you equally happy, and that's ok! It's an experiment! Here are some ideas and questions to help you get creative…

- Try different fastener styles (see photo). What style do you like best, and why?
- Is there anything around your house that might use links as a *mechanism* for movement, like an ironing board, collapsible drying rack, foldable chairs, or adjustable lamp? Can you make a simple model of a linkage you found?
- Can you engineer a linkage to move in a particular pattern?
- Do any of your toys have visible linkages? Do any of your toys and games involve playing with linkages?

What's going on?

When you move your linkage, what sort of patterns does it make? Does each part of your linkage move in the exact same way? When you add new links to your linkage, does it make the movement simpler or more complex?

Linkages can be very simple or very complicated, but the goal is always the same: to achieve a particular pattern of motion. The simplest linkage we can make also serves as one of the simplest machines: a lever. Seesaws on playgrounds are examples of both a lever and a linkage. Now that you have built your own linkages, you may be able to visualize how a seesaw is a linkage—specifically a hinged joint linkage—similar to the ones you built earlier. Let's call the long board of a seesaw—the part that you and your friend sit on—a link, and let's call the point where that board pivots a node. A seesaw therefore has one link with a node in the middle of it that attaches to another link that goes into the ground. Can you see a seesaw as a hinged joint linkage?

And if the goal of a linkage is to achieve a particular pattern of motion, what is the goal of the seesaw linkage? To move you and your friend up and down, up and down.

Not only are linkages designed to achieve a particular pattern of motion, they are also designed to either apply or withstand a certain amount of force. Linkages are often found in construction equipment, specifically around the buckets of excavators, backhoes, and front-end loaders. The operators of these big machines need to move their buckets precisely when filling and emptying them, and the buckets need to apply and withstand forces as they load and unload gravel, dirt, snow, sand, and other materials.

Now that you know the role linkages play in our lives—to accomplish a particular pattern of motion using a certain amount of force—you may start to notice them more. They are hidden away in our toys that move and the steering systems of our airplanes and cars, but are quite visible in some of our musical instruments and common household tools like scissors. Your own body even has linkages. Remember when we made our first linkage called a hinged joint? Your fingers, elbows, and knees operate as hinged joints, too. You likely used your own hinged joints when making your linkages today!

Discovery Museum Linkage Challenges

Challenge 1

Can you engineer a linkage with at least three links to allow you to raise a paper hand in class?

- Create a hand you can connect to a link.
- Engineer a set of linkages to raise the hand.

If you used a triangle, did your linkage move the way you expected?
What happens to the movement if you add more links?
Do you like to draw your designs before you build them?
Can you design two different ways to raise your hand?

Challenge 2

Can you engineer a linkage so that the end of one of the links moves in a straight line? Imagine securing a pencil to the end of that link (or do it for real!) to help you visualize the pattern of motion. How straight of a line can you make? (Hint: Try using a closed shape in your solution.)

Would joints other than a hinged joint be helpful?
What other types of joints do you want to make?
Can you design two different ways to make a straight line with a linkage?

Share your discoveries with us!

We want to know about your Linkage creations. Share your experience with us in any of the following ways:

- Draw a picture
- Take photos of your Linkages
- Write down which supplies were your favorites to use, why you liked making your own Linkages exhibit, what game you made up, or any other fun things about your linkage creations.

Then email us at myhomediscoveries@discoveryacton.org, we can't wait to hear from you!

And next time you're at the Discovery Museum, check out our Rigamajig exhibit in our Simple Machines Gallery and show us what you learned from the exhibit you created at home. Also be sure to visit our da Vinci Workshop and see what linkages you can make there using different materials. We'll see you here!

Want even more fun with linkages?

Check out these resources!

Activities:

- Making animals with linkages: https://snapguide.com/guides/make-cardboard-animation-with-linkages/
- Linkages tutorial: https://nysci.org/tutorial-linkages/

Videos:

- Mechanical toys that use Linkages: https://www.youtube.com/watch?v=OosLi1tL7rU
- Kinetic sculptor Arthur Ganson uses a lot of levers in his work. Be inspired! https://www.youtube.com/watch?v=5qeaP6LmS64