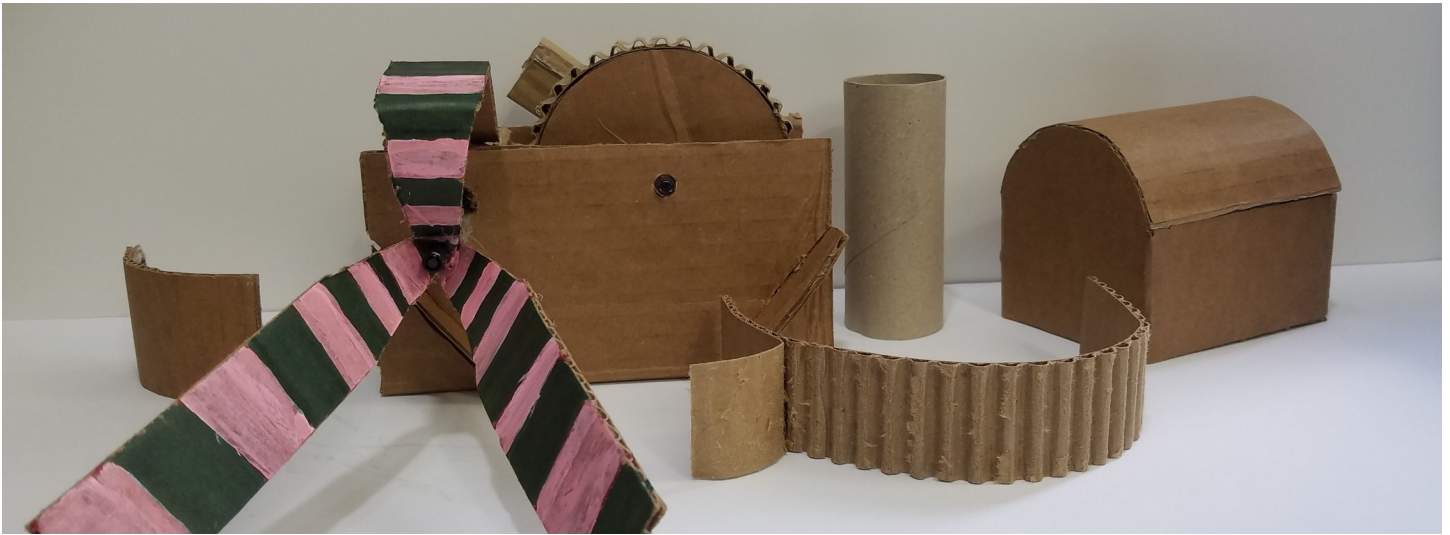


Cardboard 101



Why Cardboard

Cardboard modeling is a staple skill of professional industrial designers and amateur model makers alike. Why wouldn't it be? Cardboard is inexpensive, easy to work with, abundant, and has an excellent strength per weight ratio. At Inventionland, all of our three-dimensional design projects are realized in cardboard long before the first prototype is built or the first computer model is rendered.

Kinds of Cardboard

The first key to effectively modeling with cardboard is understanding that not all cardboard is created equal. Each different kind has its own advantages and disadvantages.



Cardstock and Poster Board

Cardstock is essentially thick paper. To make a comparison, a sheet of typical printer paper is rated as 20 pound paper. In this case *pounds* refers to the thickness. The "heavier" the paper, the thicker it is. Click [here](#) for an article that is *ridiculously complex on the subject*. Card stock, like the kind used for business cards, is typically rated at 90 to 110 pounds. It is available at most office supply stores and most desktop computer printers have the capability of printing on card stock.

Poster board is thicker than cardstock, but is easier to find in large sheets. Oftentimes dollar stores will carry poster board as cheap as fifty cents per sheet. They will sometimes have different colors available as well. Poster board and cardstock are also easily cut with safety scissors.

While both cardstock and poster board have these advantages, neither are as thick, cheap, or readily available as cardboard.

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Chipboard

Chipboard is thicker and stronger than poster board. It is the material used to make notebook covers, cereal boxes, case boxes for cans of soda and boxes for the bulk of small-to-medium sized consumer products. It's also used to make the cardboard tubes at the center of rolls of toilet paper, paper towels, and gift wrap.

Note: Paper towel and toilet paper tubes can be very useful for building cardboard models. Make sure to keep a few in your cardboard supply!

Because chipboard is used to box so many products, obtaining it is as simple as not throwing away some boxes! (How's that for cheap?) Also, chipboard can be cut with scissors although it is a bit more difficult.

Corrugated Cardboard

When most people imagine cardboard, [corrugated cardboard](#) is what they think of. Typical corrugated cardboard is nothing more than a sheet of paper with a pattern of tiny waves (called corrugations) sandwiched between two other sheets of paper that have been glued to each side. The most common use for corrugated cardboard is to make case boxes used for shipping products. It has excellent compression strength when force is applied on the axis of the corrugations. It also has very good bridging strength as long as both ends of the corrugations bearing the load are supported.



Figure 1: The corrugations shown here run vertically. They can support a LOT of weight!



Figure 2: The corrugations shown here run from brick to brick. In this way, they have excellent bridging strength.



Figure 3: The corrugations here run from front to back. In this way, they collapse

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VIDEO CONTENT: Click [HERE](#) to see a short video that demonstrates the strength and weakness of corrugated cardboard.

Corrugated cardboard readily collapses along the corrugations when force is applied in a way where one or both ends of the corrugations are not supported. That means that it bends easily in one direction but is extremely resistant to bending in the other.

Corrugated cardboard comes in a range of thicknesses referred to as “flutes.” See the chart below for standard flute thicknesses:

Flute	Thickness in inches	Thickness in mm
A flute	3/16”	4.80
B flute	1/8”	3.20
C flute	5/32”	4.00
D flute	1/16”	1.60
F flute	1/32”	0.80

Working with Cardboard



Cutting

While cutting cardstock, poster board, and most chipboard can be done easily and safely with scissors, corrugated cardboard can be much more difficult. Even when you succeed while using scissors, the edges often look torn and uneven.

There are other tools available that are for cutting corrugated cardboard. This section will discuss the different options available as well as their advantages and disadvantages.

WARNING: The following section talks about a variety of cutting tools. ANY time children have access to cutting tools of ANY kind, they should be supervised by an adult. Many of the tools listed are DANGEROUS. Use discretion when deciding what is the best and safest option for your students.

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Safety Scissors

As mentioned above using safety scissors can be difficult and the results are rarely attractive. The advantage, however, is that just about everyone has access to scissors. Most households have several pairs in one place or another. Scissors are also cheap; most dollar stores have scissors for sale for a dollar. Lastly, scissors are relatively safe. Most children can safely use scissors SUPERVISED within first grade.

Cardboard Scissors

Sometimes called “corrugated cardboard scissors” or “cardboard cutting scissors,” these heavy duty scissors feature thick, angled blades that easily cut through corrugated cardboard as well as many other craft materials. They often have large, ergonomic handles that give the user plenty of leverage and control as they cut. These scissors are relatively safe to use, although supervision is ALWAYS recommended, especially for young children. (See the warning above.)

The disadvantage with cardboard scissors is that they can be harder to find in stores. You won't find these at most general retailers. You MAY find them at craft, hobby, or art supply stores. They are also readily available from online retailers such as Amazon. The other disadvantage is that these items are not cheap. Online prices range from \$18 to well over \$20 per pair. Retail locations will likely charge up to \$30.

Serrated Cardboard Cutters

These cutters at first glance look like a knife, but upon closer inspection reveal that the “blades” are lined with tiny serrations. These tools ARE NOT SHARP. The blades feel dull to the touch, making them a very safe option, especially for younger students. (See the warning above.)

While it would be difficult to cut skin with these cutters, they are tremendously effective when used on cardboard. Simply use a back and forth motion while cutting and let the blades do the work. Smooth controlled cuts are made safely and easily using these cutters.

Much like cardboard scissors, there are two significant drawbacks with serrated cardboard cutters. The first is that they are more difficult to find at retail locations. Again, a person MAY be able to find them at craft, hobby, or art supply stores, but it is unlikely they could be found elsewhere. The second drawback, again, is price. A single cutter can cost around \$10. Price breaks can reduce the per unit cost, but the customer must buy more at one time to get the savings.

At the time of this writing, we could only find one company making this product. A company called “Canary” sells their “Canary Cardboard Cutters” on Amazon. There are a variety of different styles, but they all feature the “safe” serrated blade.

Hobby Knives and Utility Blades

Hobby knives and utility blades are by far the **MOST DANGEROUS OPTION** for cutting cardboard. In the history of Inventionland, the tool that has been involved in the **MOST** accidents requiring a person to go to the hospital has been the hobby knife. These blades are insanely sharp and easy to lose control of. We do **NOT** recommend these tools for students.

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That being said, if a teacher or other responsible adult chooses to use tools like these, there are advantages to them. First of all, both (when sharp) are extremely effective at cutting cardboard. The cut edges of the cardboard will be crisp and clean. Hobby knives are the tool of choice for most industrial designers and hobbyists because of the highly detailed and precise cutting that can be done with them. Also, they are easy to come by. Both hobby knives and utility blades can be found at office supply stores, hardware stores, home centers, and sometimes general retailers. They can also be found at most craft, hobby, and art supply stores. Of course, they are also available from online retailers as well. Replacement blades are as easy to find as the tools, usually being sold by the same retailers. These tools are also relatively cheap. While there are always more expensive name brands, non-name brands can cost only a few dollars for the tool, which will usually come with a small number of replacement blades.

Aside from the aforementioned danger, another drawback of hobby knives and utility blades is that the blades dull quickly as they are used. For best results, blades should be changed often which is sometimes inconvenient, and can start getting costly during large projects. Additionally, dull blades lead to accidents. A person will instinctively use more force as their blade gets less effective. When that happens the blade can easily slip or break, causing the user to cut themselves, or someone else by accident.

VIDEO CONTENT: Click [HERE](#) to see a short video about different cardboard cutting tools.

Making Cardboard Bend to Your Will

It seems counter-intuitive that bending a material made of paper would be challenging, yet anyone who has spent time working with the material can tell you that it rarely folds in predictable or desirable ways without using a few tricks.

Scoring:

Have you ever tried to fold a piece of cardboard, but instead of a nice straight line, like you get when folding paper, the fold looks uneven and irregular? Cardboard of all thicknesses tends to fold in irregular ways unless you score the cardboard before you attempt to fold it.

Scoring is the act of weakening a piece of material along a line where you intend to fold the material. This is done by drawing a line where you plan to make the fold, then tracing that line using a ruler and some kind of rigid stylus to press into the material and create a crease for the fold to follow. The stylus can be any rigid implement that comes to a dull point. Here are some things you can try:

A clicker pen with the tip retracted.

A pen with the cap on if the cap has a pointed top.

A stick or dowel rod sharpened to a dull point (like with a pencil sharpener).

A ball point pen that has dried up.

The tip of a pair of scissors with the blades closed.

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Corrugated cardboard can be difficult to score as it will often tear instead of crease. When this is the case, try pressing the cardboard flat with your finger or your knuckle along the path of the desired fold, then score it as described above. Flattening the corrugations mashes the layers of paper close together so that when you score them the top layer is supported by the next, and thus will be less likely to tear.



Rounding:

Sometimes you don't want a hard fold line. There are times you may want to create a shape with a round surface. Think of a hat box which is usually a large cylinder or a treasure chest with its curved lid. You may think that shapes like those can't be made with cardboard, but you would be mistaken.

To get corrugated cardboard to take on a curved shape, follow these steps: First, flatten the corrugations. Use a rolling pin, your hand, or something else, but make sure you've mashed the corrugations flat through the entire piece you need to curve.

Next, place your cardboard on a table top with the end sticking out over the edge.

Then, grasp the cardboard firmly with one hand while applying pressure on the cardboard right over the edge of the table with the other hand.

Finally, pull the cardboard out and down across the edge of the table.

Do this several times and necessary to achieve the desired curve.

VIDEO CONTENT: If the description above seems like a lot to read, click [HERE](#) for a short video that demonstrates everything discussed above.

Glues Clues!

It's all well and good to know how to cut, fold, and shape cardboard effectively, but those techniques won't get you very far unless you are also able to put your cardboard pieces together. In this section we'll go over different methods of attaching cardboard. We'll point out the pros and cons as well as how to choose the best methods for your projects and resources.

Gluing and Taping

While it may seem like glue and tape are totally different methods of bonding things together, they are similar in that they both rely on chemical adhesives to bond things to the surface of the cardboard. Due to that, some of the techniques to be most successful are consistent for both. Here are a list of practices to help make sure your cardboard projects stick together:

- Make sure your cardboard is free from dust, dirt, oil, or moisture.
- Press the surfaces to be bonded together firmly to maximize the surface area of the joint, and to squeeze out air gaps.
- When gluing pieces, hold them in place and don't move them until the glue has had time to dry.

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Gluing options

While hot-melt glue from a hot glue gun is probably the most common method for attaching cardboard, it does have some drawbacks. For one thing, hot glue sticks tend to get used up quickly. If you have a large project, make sure to have a good supply of hot glue sticks. Also, not everyone has a hot glue gun available to them. They are readily available at a number of retailers, but sometimes you may just want to use what you have at your disposal rather than buying something new. Most notably, hot glue guns are HOT and require plugging in to a wall outlet. Young children can easily burn themselves or get an shocked if they use a hot glue gun improperly.



For any of these reasons you may want to consider other options for your cardboard bonding needs. Here are some possibilities:

White Glue or Wood Glue

You can achieve an amazingly strong bond when using white glue or wood glue on cardboard. The trick is to know how to use it; with both products it's essential not to use too much. These glues are both water based. Students commonly use so much that their cardboard becomes a saturated mess. The best way to use these glues is to use just enough to spread a thin even coat over both surfaces. The layer should be thin enough as to appear clear. If you can't see through the glue, you're using too much!

Rub the glue into the surface of the cardboard as you go to ensure a good bond then, while both surfaces are still tacky, press them together, twisting them in relation to each other to ensure the glue on both surfaces mix. You will find that as you work with the pieces they will become harder to move around. At that point make sure they are positioned correctly and hold them in place. This is a good time to set them aside with weight on the bonding parts. Leave them alone for at least 20 minutes though the longer they are left, the better.

While that might seem terribly inconvenient, it is actually quite effective with practice. Also, it is important to note that white glue and wood glue are inexpensive, available just about anywhere, and are non-toxic. As both glues are water based, it is easy to clean as long as any spills or spots are caught before the glue dries.

Glue Stick

Glue sticks can also be used to bond cardboard. It dries quicker than white glue, but the bond is not as strong. To use it effectively, you should thoroughly cover both surfaces intending to be bonded, and then quickly stick them together before the glue starts to harden. This means that one stick will not last very long on a large project. On the plus side, the glue is non-toxic, water soluble, and relatively inexpensive.

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Contact Cement

Contact cement is an effective option that has a modest price tag. It's certainly more pricey than white glue, but most things are. To use contact cement, apply a thin layer of cement to both bonding surfaces then let them get mostly dry. The surfaces should feel just a bit tacky before you press the surfaces together. If done correctly, the parts will bond instantly. Give the parts time to fully harden or "cure" before handling.

Does it sound too good to be true? Well, consider these definite drawbacks: the fumes from contact cement are potent, powerful, flammable and dangerous. It should only be used in a well ventilated area and even with that, you should wear a respirator. Cover your work area because it is messy to work with. You should typically apply it with a brush, but your brush will quickly become a sticky, boogery mess as layers of cement build up and start to harden.

For all these reasons, it should only be used by responsible adults following all the safety standards, never by children. (See warnings above.)

Using Tape on Cardboard

If glue is unavailable or undesirable, there are several kinds of tape that can be effective to bond to cardboard. The advantage with tape is that it's relatively safe and is not messy. Bonds are instantaneous, so work goes quickly. Many kinds of tape are reasonably priced and readily available.

Tape quality and adhesion can vary greatly from one brand to another, so understand even if a tape is listed here as working to stick to cardboard, always test a small amount before committing to buying enough to do an entire project.

The kinds of tape that commonly stick to cardboard are clear tape, packaging tape, strapping tape, and duct tape. (Although duct tape is sometimes hit or miss depending on the brand.) Getting a good bond with tape can be extremely challenging because in most common applications it does not bond the mating surfaces together. Instead, it tethers one piece to another via a shared adhesive strip. Depending on the application, even tape that sticks, may not be effective at holding your project together.

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Cardboard Attachment Techniques

When putting together a cardboard model, there are things that can be done to make the joints between bonded parts stronger. Most of these involve adding tabs for gluing in some way to greatly increase the surface area of the glue bond. Some of these techniques, however, allow you to join parts together using no glue at all.

Tabs

Tabs are small extensions of cardboard that fold out from the mounting surface of the piece to be glued. They work by providing more surface area to contact the mating part thus creating a stronger glue bond.

Tabbed Gussets

Gussets are small triangular pieces added to the inside of a corner to make the joint stronger. Adding tabs to the gussets increases the surface area being glued. The effect is a reinforcement for inside corners that is incredibly strong and rigid.

Flanges

Flanges are essentially tabs that go all the way around the base of a part. They can be used to attach a three dimensional object securely to a flat surface by supporting it all the way around the joint.

L Brackets

L Brackets are essentially folded pieces of cardboard that overlap a piece and the part that the piece attaches to. It's very much like making a piece of tape out of cardboard and glue.

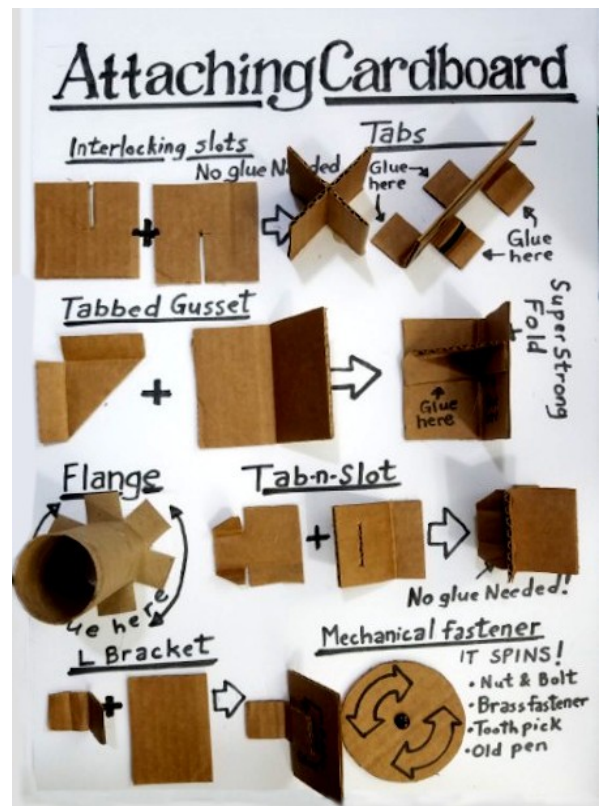
The following techniques require no glue to attach cardboard together:

Interlocking Slots

Interlocking slots are thin slots cut into two pieces of cardboard that intersect each other at an angle to allow the two pieces to hold themselves together. The slots must be cut slightly thinner than the thickness of the cardboard so the friction of the mating piece in the slot will help hold the pieces together.

Tab-n-Slot

A tab-n-slot is a tapered tab that has slots cut on either side of it. The slots allow the end of the tab to be folded in on itself from both sides. The tab is then inserted into a slot cut into the mating part. The slot must be just wide enough for the folded tab to squeeze through, but narrow enough that when the ends of the tab are folded back out they retain the tab locking it into the mating part.



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Mechanical Fasteners

A mechanical fastener can be any kind of object used to join two parts. The fastener is inserted through a small hole in each part where the parts are retained either by friction or by features of the shapes of the fasteners. Some possible mechanical fasteners include:

- Nuts & bolts
- Brass fasteners
- tooth picks
- wooden skewers
- dowel rods, used pens or pencils.

One unique feature about mechanical fasteners is that if only one is used, it will essentially become a pivot point around which a mating part can rotate.

Getting Creative

At this point you have learned about different types of cardboard, the structural properties, corrugations and a variety of different cutting tools that you can use. You've also learned about different adhesives and how to use them as well as different techniques that make bonding with adhesives easier and more effective. But is that it? Is that everything there is to know or do with cardboard? The answer is an emphatic "NO!"

Now it's time to stretch your imagination and think about what other ways you can use cardboard to create amazing models. Try peeling the outer layer of paper on a piece of corrugated cardboard. Look at the pattern of corrugations that make up the inside. What ways could you use that texture in your models? Here are some possibilities:

- Roll a piece of exposed corrugations into a cylinder. Use it as the trunk of a tree.
- Wrap the corrugations around cardboard wheels to create gears that work!
- Cut a piece of exposed corrugations into thin strips then glue them into a loop to make the treads on a bulldozer.

These are just a few of infinite possibilities that are available to you when you are armed with some practical information, a minimum of supplies, an abundant and versatile building material and a lot of imagination!

