Paper Engineering and Pop-Up Demonstration by Carol Barton

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Paper engineering is the art of mechanizing paper. It encompasses the design of threedimensional paper forms which are folded flat between a closed page spread and "pop-up" with the action of opening the page. Paper engineering also covers the design of mechanisms such as pull tabs and rotating wheels whose movement is activated by the reader or viewer, but these will not be covered in this demonstration. (For information on movable mechanisms, please refer to the accompanying bibliography).

Although there are dozens of structural forms and variations on these which compose the language of skilled paper engineer, the five basic structures presented in this demonstration form the basis of most dimensional pop-up structures. Pop-ups today are most often associated with children's books, but they can bring magic to adult editions as well. As a sophisticated form of paper architecture, a pop-up can add an elegant sculptural element to the well-designed page. However, the addition of a pop-up to an edition can add much more time and hand work to a project, depending on the complexity of the piece.

Simple Symmetrical Non-Adhesive Pop-Ups

The simplest type of pop-up is one which is symmetrical and centered over a fold. (All popups must cross a fold, the mechanism which drives the movement in the pop-up). This type of pop-up is the easiest to fabricate because it does not require any gluing of separate parts; the popup is integral to the page. This pop-up works with the page less than fully opened flat.

Symmetrical pop-up made with Two Cuts.

There are two types of symmetrical pop-ups. The first involves two cuts made into the fold of the page with a hinge-fold between the cuts.

To construct an example of this pop-up, fold a piece of $8.5 \times 11^{\circ}$ paper in half to $8.5 \times 5.5^{\circ}$, then open the page and fold it in half the other way.

Holding the paper folded lengthwise, make two 1inch cuts into the fold which are 1 to 2 inches apart. Next fold the tab of paper between the cuts back and forth, then pull this tab back flat. Open the entire page and fold it top to bottom in the direction you first folded it.





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Using both hands, press one thumb above and the other below the cuts and pinch the card partially closed, which should push the pop-up forward. If the pop-up does not automatically push forward, pull it forward with a finger as you close the card.

(Note: A pop-up like this will work on a singlefolded piece of paper, but the cut-out hole will show and it will not automatically push forward into position).

Many variations of this simple form can be achieved by changing the length and shape of the cuts, the distance between them, the angle of the hinge-fold, etc. In fact, any symmetrical shape can be made to pop up in this way as long as a hinge connects it to the page in the same position on both sides.

Symmetrical pop-up made with One Cut. (Triangular Pop-Up) The second form of symmetrical non-adhesive pop-up is made with a single cut and an angled fold extending off the cut.

To construct an example of this form, again fold a piece of 8 1/2 x 11" paper in both directions, then holding the paper folded lengthwise, make a single 1-inch cut into the fold. Press the paper on either side of the cut back at an angle to create a triangular tab. Fold this tab back and forth, then pull it back flat. Open the page and fold it top to bottom in the same direction as before. Press one thumb at the peak of the triangle, the other below the cut and pinch the card closed to push the pop-up into position. If it does not pop-up automatically, pull it forward with a finger as you close the card.

Again, you can achieve variations on this basic form by varying the length and shape of the cut and the length and angle of the fold. Folding a triangle off both sides of the cut results in a mouth-like pop-up.









Multi-layered symmetrical pop-ups. Several layers of these simple symmetrical pop-ups can result in more elaborate forms. The folds of each successive pop-up layer provide positions for additional pop-ups. (Remember, a pop-up must cross a fold). Each successive pop-up will move in the opposite direction as the fold it crosses: pop-ups over valley folds will push outward, those over mountain folds will push inward.

V-Fold Adhesive Pop-Ups

The V-fold pop-up is one of most strongest and most versatile paper engineered forms. It requires gluing, which does represent additional handwork. The V-fold works with the page fully opened flat. Several V-folds can be layered on a single page to create landscapes and theatrical scenes.

To construct a V-fold, cut any shape with a flat base at least 5" wide from a piece of text-weight paper. The shape can be asymmetrical or symmetrical. Fold the shape approximately in half (the fold can be off-center) at a 90 degree angle to the flat base. Fold up a 1/2-inch tab along the entire baseline, then split this tab into two tabs at the central fold.

Fold an 8.5 x 11" piece of card stock in half to 8.5 x 5.5". Hold the pop-up folded in half with the tabs extended (see illustration) and visually position it into the card-weight folder, making sure that (1) the point in the pop-up at which the centerfold meets the baseline fold lies along the centerfold of the folder, and (2) the folded edge in the popup lies at an angle to the folder's centerfold.

Apply glue to the face of the exposed base tab and fold the folder down onto the tab. Open the folder and repeat this procedure on the other side. The resulting pop-up should stand straight up off the page.

The relationship between the centerfold and baseline fold in the pop-up determines the orientation of the V-fold. By reducing this angle from 90 degrees you can design a V-fold which leans forward or backward. At 45 degrees, the pop-up will not function properly.







glue tab



Asymmetrical pop-ups

These pop-ups are similar to symmetrical oneand two-cut pop-ups, but they fall unevenly across a fold. They work with the page opened to 90 degrees, and can be designed either as an adhesive addition to a page or as an nonadhesive pop-up integral to the page.

The basic formula for an asymmetrical pop-up is that the tab attaching the image to the vertical back of the page must equal the distance from the page centerfold to the base of the image.

To create an adhesive asymmetrical pop-up, cut out an image with a flat base from a piece of textweight paper and fold up a 1/2-inch tab along the bottom of this image.

Fold an 8.5 x 11" piece of card stock in half to 8.5 x 5.5". With this folder in the portrait position, glue the base tab of the pop-up image into the folder below and parallel to the folder's centerfold.

Measure the distance from the folder's centerfold to the base of the pop-up image. From a piece of card stock, cut a strip which is one inch longer than this to allow for two 1/2-inch glue tabs on either end. This piece can be as wide as the image, and should be at least 1/2-inch wide.

Fold down two 1/2-inch glue tabs at either end of the card stock strip and glue one of the tabs to the back of the pop-up image, parallel to the base of the image. Push the image forward toward the foredge of the folder. Pull the card stock strip back toward the folder's centerfold with the glue tab extended flat. Apply glue to this tab and fold the folder down onto it. The result is a pop-up which stands up parallel to the vertical back of the page.

Several images can work in a single folder. Each image's tab must be based on the distance from the folder's centerfold to the base of that image. When designing a non-adhesive version, tabs must extend from a fold along the top of each image, and all images must be plotted out before the piece is cut and constructed; otherwise extra centerfold lines will weaken the tabs.





Floating Planes

These pop-up forms float above the plane of the page. Again, this is a very versatile and strong structure, and works with the page opened flat.

To construct a floating plane, cut any shape out of a text-weight piece of paper and fold it approximately in half.

Cut three tabs out of card-weight paper which are about 1 inch wide and 2 inches long, grain long. On each of these, fold up a 1/2-inch glue tab both ends (see illustration).

Attach one of these tabs along the valley side of the central fold of the cut-out shape. Attach the other tabs, one to either side of the center tab, parallel to the central fold and facing "in" toward the center. (see illustration). The cut-out shape should look like it's standing on three "feet".

Fold an 8.5 x 11" piece of card stock in half to 8.5 x 5.5". Glue the center foot of the pop-up along the centerfold of the card-weight folder.

Push the pop-up to one side of the folder with the center foot fully extended, and pull the side foot so it is fully extended back toward the centerfold. Apply glue to the glue tab of the foot and fold the folder down onto the tab. Repeat this procedure on the other side.

The result should be a pop-up which "floats" above the page. More feet can be added on either side of the pop-up for more support, but they must be positioned parallel to the centerfold.









Die-Cutting

Die-cutting is the process of using a press to cut and/or score paper. A die looks like a cookie cutter set into plywood. Knife-sharp blades cut through the paper, while dull rounded blades press in a score line. Foam rubber pads glued on either side of the knife blades hold the paper during this process.

Today there are special commercial presses made specifically for die-cutting. However, diecutting can be done easily on either a platen or cylinder letterpress. A protective metal jacket should be wrapped over the bed or around the cylinder of the press during the die-cutting process to prevent damage to the press. When ordering a die to be used on a letterpress, be sure to tell the diemaker that the die must be "type high."

To locate a die-maker, look in the yellow pages under "die-cutting". Provide the die-maker with an exact line drawing of the die, showing solid cut lines and broken score lines.

I mail order my dies from:

True-Line Dies 481 Washington Street New York, NY 10012 212-966-2848

Bibliography

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Available from:

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