**How Many Images?**

**Purpose:** to apply the reflection principles to a mirror system which causes multiple reflections and determine the relationship between angle between the mirrors and number of reflections observed

**Procedure:**

Place the two mirrors at an angle of 90o. Place the object to be observed inside the angled mirrors.

90o angle

Count the number of images resulting from these multiple images. Explain the reason for these multiple images.

\Change the angle of the mirrors and count the number of images. Chart the angle and images below.

|  |  |
| --- | --- |
| **Angle of mirror** | **Number of images** |
| 90o |  |
| 72o |  |
| 60o |  |
| 40o |  |
| 30o |  |
| 20o |  |

**Conclusion:**

Summarize your findings. Be sure your summary includes

* how this experiment illustrates the law of reflection for mirrors
* the relationship between the angle and the number of images – qualitative and quantitative
* how your experimental findings might relate to the construction of a kaleidoscope

Modified from an activity in the original PRISMS project <http://www.uni.edu/prisms/original-prisms>

**WHAT IS A KALEIDOSCOPE, AND WHERE DID IT COME FROM?**

In 1816, **Sir David Brewster of Scotland** was the first person to invent the concept and object called the 'kaleidoscope.' He stumbled upon it through experimentation with prisms and other optical tools. He created a tube-like instrument that contained loose pieces of glass and other objects that were reflected by mirrors and/or lenses set at different angles to create various symmetrical patterns when viewed through one end of the tube. Brewster's term for this new instrument, "kaleidoscope," came from the Greek words meaning, "beautiful-form-to see."

**WHAT'S INSIDE A KALEIDOSCOPE?**

The interior of a kaleidoscope can consist of 2,3,4, or more mirrors that run the full-length of the inside of the scope. The **angles** of the mirrors will determine the number of reflections viewed. (Smaller angle = More reflections of object viewed.)

**Example (for a two-mirror system):** A ten-degree angle, divided into 360 degrees (the number of degrees in a circle), gives you 35 reflections or an 18-point star (since 18 of the reflections will be reversed from the original. A 45-degree angle divided into 360 degrees gives you 7 reflections or a 4-point star. The image shown below has a 22.5-degree angle.

The **quantity** of mirrors determines the shape and style of the image seen. A *two-mirror* system (below, left) will make a cathedral window or [mandala](http://www.kaleido.com/faqs.htm#Mandala)-like image. There are no side reflections, only a single circular pattern. (Another example: Janice Chesnik's [Dichroic Glass Image](http://www.kaleido.com/images/jcimg_lg.gif).) A *three-mirror* set (below, center) will reflect the pattern throughout the inside of the "tunnel" of mirrors. A *four-mirror* system will result in either a series of rectangular images, or a symmetry pattern that has a double center point. Below right is an example of a rectangular arrangement of three mirrors and one black side. The reflections of the image continues indefinitely in a straight line. (Images below are from: [Massimo Strino's](http://www.kaleido.com/massimo.htm) *King Arthur*, [Lawrence & Audrey Goldsmith's](http://www.kaleido.com/goldsmith.htm) *Flower Shower*, and [Steve & Peggy Kittelson's](http://www.kaleido.com/kittelson.htm) *Brocade*, respectively.)

[](http://www.kaleido.com/massimo.htm)[](http://www.kaleido.com/Kalish.htm)

The mirrors of the kaleidoscope are its heart. The best mirrors to use are *first- or front-surface mirrors,* (where the silvering is on the front of the glass) which give sharp, clear reflections. Conventional (or back-surface) mirrors (where the silvering is on the back of the glass) may also be used, but they create duller, more blurred reflections. Plexiglass mirrors are often used in children's scopes to lessen the chance of injury in case of breakage.

**See our** [**Mirror Page**](http://www.kaleido.com/mirrors.htm) **for more details about Kaleidoscope Mirror Systems,  
or visit the** [**Brewster Society's Mirror Page**](http://www.brewstersociety.com/mirror_config.html) **for more mathematical details.**

**HOW IS THE REST OF THE KALEIDOSCOPE MADE?**

The kaleidoscope can have a fixed or detachable object case at the end of the mirror tube which gives the scope its images. Object cases (or cells) can contain or be made of: stained glass, dried flowers, agates, clear or colored oils, beads, marbles, semi-precious stones or practically any transparent, colored object! Some object cases are designed to let the owner of the scope interchange different cells on the end of a scope, or open the cell and add to it whatever his or her heart desires.  
  
The exterior of a kaleidoscope is where the scope artist can be really creative. Although a scope's interior is very important, the exterior is what sells it. It's what catches the buyer's eye first. The exterior can be carved, turned, sculpted, welded, and can be made out of any attainable resource, such as: brass, copper, stained glass, wood, paper, fiberboard, plastic, fabric, leather, and so on.

**HOW CAN I MAKE A KALEIDOSCOPE?**

We offer a couple of good books for beginning scope-makers on our [Resources](http://www.kaleido.com/resource.htm#books) Page, along with a short list of suppliers. Also, there are usually a couple of classes listed on our [Special Events](http://www.kaleido.com/spevents.htm#classes) Page. Our [Kits Page](http://www.kaleido.com/kitspage.htm) offers some simple kits for the beginning scope artist. **But that's about all we can tell you about actually making scopes. We don't know where to find object cells for oil-filled scopes other than the suppliers we list on our Resources page. Sorry!**

**HOW CAN I TAKE A PICTURE THAT LOOKS LIKE A KALEIDOSCOPE IMAGE?**

There are filters which attach to the lens of a 35mm camera which make a simple kaleidoscopic image out of whatever you focus the lens on. You can find them at better camera stores (such as National Camera Exchange in the Twin Cities area). For more details, see our [Scope Photography](http://www.kaleido.com/ScopePhoto.htm) page. Otherwise, we do have an artist who makes an attachment for a camera which uses mirrors to create a kaleidoscopic image. See the [Mark Reynolds](http://www.kaleido.com/reynolds.htm) page for more information on this attachment.

**WHY IS THERE SUCH A BIG INTEREST IN KALEIDOSCOPES?**

Kaleidoscopes are works of art. Just like a Rembrandt or a Picasso painting, the Kaleidoscope adds taste and decor to anybody's home or office. (Artist and collector [Judith Paul](http://www.kaleido.com/JPaul.htm) wrote an excellent article for the [Brewster Society's](http://www.kaleido.com/brewster.htm) Newsletter several years ago entitled [*"Modern Kaleidoscopes - Collecting and Investing"*](http://www.kaleido.com/Collecting.htm) that the Brewster Society has allowed us to reprint.)

Like anything of value, the kaleidoscope can appreciate in value if the owner takes proper care of it.

The Kaleidoscope can be a tool or resource for relaxation and meditation. One's mind can be put into an imaginary world while looking through the scope. Some doctors and psychiatrists have been known to let their patients use a scope to calm and relax themselves. The kaleidoscope can relieve tension or stress. It can give the imagination a great and wonderful work-out.

Since the 1870's, the kaleidoscope has become a treasured object to collect. The variety of types is unlimited, so the collector can always add to his or her collection.

<http://www.kaleido.com/faqs.htm#makescope>

The kaleidoscope makes magic with light and mirrors. It may be considered a child's toy (or a toy for all ages), but it is also a simple optical device with technical applications for designers and pattern-makers. Greek words are the source of the name; it comes from *kalos, eidos,* and *skopios* meaning beautiful, form, and view, respectively.

**Background**

The body of the kaleidoscope has two main parts, the viewing tube (with an eyepiece at one end) and the object box or case at the opposite end of the tube. The object box is a thin, flat box made of two glass disks and a band circling the edges and holding the disks and the objects enclosed. Those objects are fragments of colored glass, beads, tinsel, or other reflective materials.

The outer disk of the object box is ground so it diffuses the incoming light; that is, it acts like a screen. The viewing tube has a glass eyepiece at one end; it may be ordinary glass or an optical lens with magnifying properties. Inside the tube, three strips of mirrors are joined to form a triangle; the angles of the mirrors also affects the view through the kaleidoscope. Typically, they are angled at either 45° or 60°. When the object box is turned or tapped, the glass or objects inside move and tumble freely. As the viewer looks through the eyepiece toward a light source, the mirrors produce symmetrical order out of the tumbling objects and multiply them six, eight, or more times depending on the angles of the mirrors.

A variation of the kaleidoscope—the teleidoscope—replaces the object box with another lens that allows the viewer to look at a distant object and view it in multiples. Still other variations use more mirrors. Two mirrors have the advantage of producing a centered pattern; multiple mirrors split and duplicate the image many times over. The kaleidoscope is infinitely entertaining because the patterns and combinations are endless and are not permanent unless photographed.

**History**

Although the ancient Greeks, including the mathematician Ptolemy, had contemplated the effects of abutting multiple mirrors, the kaleidoscope is the creation of one man. David Brewster (1781-1868) was born in Scotland and educated to become a minister at the University of Edinburgh. University studies exposed him to the wonders of science, however, and he abandoned the church in favor of studying the properties of light. He became an expert in polarization of light (the linear and planar properties of light), reflection of light using metal, and light absorption. For his scientific discoveries, Brewster was elected a fellow of the Royal Society (Britain's leading scientific organization) in 1815 and knighted in 1831.

Brewster invented and patented the kaleidoscope in 1816. He described its structure and operations in a 174-page scientific paper titled *Treatise on the Kaleidoscope.* In his treatise, Brewster calculated that 24 fragments of glass in the object box of a kaleidoscope could create more than 1.4 x 1033 fleeting views. He also described the most effective combinations of colors for kaleidoscopes based on light properties. In the 1840s, he used two lenses to produce a three-dimensional effect in creating the stereoscope. He was also a leading advocate of the flat Fresnel lens adopted by the British for lighthouses and was credited with saving thousands of lives by protecting vessels against shipwrecks. Brewster taught at the University of Edinburgh and the University of St. Andrews in Scotland, was one of the first editors of the *Encyclopedia Britannica,* and published many books and scientific papers.

Following its invention in 1816, the kaleidoscope grew in popularity around western Europe, and the first one to appear in the United States was reported in 1870. It became a favorite toy for children but also an entertainment for adults in parlor games like viewing stereoscopic photographs and playing charades. The most famous kaleidoscopes, other than Brewster's originals, were made by Charles G. Bush of Boston. The Bush kaleidoscope was constructed of a viewing tube of banded black cardboard, a [**brass**](http://www.madehow.com/Volume-6/Brass.html) wheel to turn the object box, and a wooden stand. It was the objects that made Bush's version unique (and a valuable collectible today). He used 35 objects of various colors and shapes, but some were filled with liquid containing air bubbles. The air bubbles moved through the liquid even when the observer held the object case still. Bush secured the patents for the liquid-filled objects (ampules), for his method of adding and subtracting objects without taking the box completely apart, and for stands and other kaleidoscope accessories.

As a tool for designers, the kaleidoscope produces ranges of colors and patterns used to create rugs, stained glass, jewelry, architectural patterns, wallpaper, woven tapestries, and ideas for painters. The kaleidoscope fell out of popular interest in the early twentieth century, but it revived in the late 1970s when new styles and the collectible character of antique kaleidoscopes fired the curiosity of new generations. Bush's kaleidoscope with the liquid-filled objects sold in 1873 for $2.00; collectors in the early twenty-first century willingly pay over $1,000.

— *Gillian S. Holmes*

Excerpted from:

<http://www.madehow.com/Volume-6/Kaleidoscope.html>

**Raw Materials**

The types of materials that can be used to make kaleidoscopes are almost as endless as the images its mirrors produce. The viewing tube can be made of paper, cardboard, plastic, acrylic, wood, plexiglass, brass, copper, sterling silver, and other metals and materials. The endcap containing the eyehole is made of material that is compatible with the viewing tube. The eyehole or peephole and the two faces of the object case are usually made of plastic or glass. The objects in the box can be fragments of rock or minerals, gemstones, beads, glass or plastic ampules (filled or unfilled), shells, bits of glass, bits of metal, tiny trinkets, or any combination of these. The objects can be chosen based on similarity or variety in color. Inside the tube, mirrors are essential for forming the images. Tape holds them together, and some kind of padding or stuffing like newspaper, **cotton,** or styrofoam keeps the mirrors from rattling against the inside of the tube. Tape can also be used to hold the endcaps and object box in place. Other connectors or fastening materials, attachments, and trims can be made to match the look of the kaleidoscope.

**Design**

The designer of the kaleidoscope chooses the size, materials for the case, orientation of the mirrors, type of object case or rotating wheel, and objects to shape the views. All of these choices affect the price of the kaleidoscope (to produce as well as purchase) as much as the kind of images the designer is trying to create. Miniature kaleidoscopes that can be attached to a key chain to those as tall as a person have been made. Cases can be manufactured of simple materials like paper, plastic, and wood; many varieties of metals are chosen from brass to sterling silver and gold-plated models. If the kaleidoscope end is a rotating wheel, that wheel may be made of gemstones, stained glass, thin slices of agate and other minerals and rocks, and more. Object boxes may be filled with crystals, glass containing embedded threads (laticcino glass), baubles, gemstones, seashells, chips of glass, or liquid-filled capsules (ampules). Kaleidoscopes can also use light sources or light filters other than natural light. Electronic scopes, oil-suspension scopes, polarized light scopes, and projector scopes are examples.

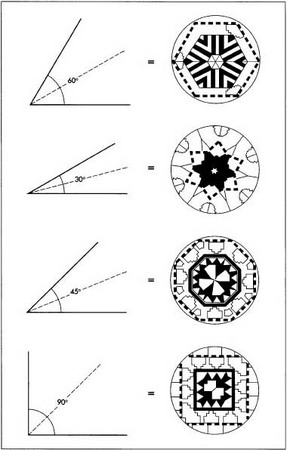
Designers may have an individual style, a material they prefer to work with, a particular type of image or view they want to create, or objectives related to pleasing their customers. Some are made to be ideal gifts, and some are unique creations for collectors. Again, many issues and ideas may motivate the kaleidoscope designer. Internationally known designer Carolyn Bennett makes kaleidoscopes from acrylics. Her viewing tubes are often square or rectangular and look like interesting sculptures from the outside as well as producing gorgeous images within. To keep costs down, she uses stock sizes of plastics and other materials, but the design always reflects the environment or the character of the collector or designer over the ease of manufacture. About half of her designs are made to suit the colors and budgets of customers that include museums and corporations; her designs made for stores suit her artist's eye with some consideration for engineering aspects and constructability.

Kaleidoscopes have generated a vocabulary describing their light-adjusting capabilities, materials, and construction. Dichromatic glass makes different colors depending on the angle light strikes it. Flashed glass is a mirror made of two colors, one overlying the other. The oil-suspension scope contains oil in the object case along with bits of glass or other materials that float in the oil. Slumped glass is heated until it bends; pieces of slumped glass are held in the object box of some designs. Hot glass is scrap glass that is heated until it fuses and then painted. The teleidoscope (combination of a telescope and kaleidoscope) replaces the object case with another lens so the tree or bird viewed through the teleidoscope is reflected in multiples. These terms and many others characterize the variety available in kaleidoscopes.

**The Manufacturing Process**

The kaleidoscope described in this section is a simple version, and many of the materials are not itemized in detail. As the sections above suggest, the choice available to budding kaleidoscope designers is almost without limits; and, although some kaleidoscopes (especially toys) are mass-produced, the "manufacturing" of a kaleidoscope is creative and artistic.

* 1 The inner diameter of the tube determines the size of the mirrors that will be inserted. The tube is selected or made, and the inner circle is drawn on a piece of paper. A compass is used to bisect the circle and subdivide it into six equal parts to measure and plan a system of three mirrors forming an equilateral triangle (a triangle with sides of equal length and internal angles that are all 60°). By connecting every other dot out of the six subdivisions of the circle, the outline of the three mirrors can be drawn and the width of the mirrors is measured. About 0.13-0.25in (0.32-0.64cm) is subtracted from the width of each mirror to allow for the thickness of the mirror. Three pieces are used to create a clear image, although the maker can choose many other configurations. The lengths of the mirror are equal to the length of the tube minus the space at the end of the tube for the object chamber. On the order of 0.5-l in (1.27-2.54 cm) should be allowed for a basic, hand-held kaleidoscope.
* 2 The kaleidoscope maker can cut his or her own mirrors or have them cut at a glass shop. First-surface mirror with the silvering on the surface is usually chosen. Next, the mirrors are taped together to fit inside the viewing tube. This is done by fitting the mirrors together with one hand imitating the tube and with the other free to tape. The mirrors are aligned so the edge of one mirror is seated on the surface or face of the adjacent one, which in turn has its edge seated on the face of the third. If the mirrors are connected edge to edge rather than edge to face, the image will be skewed. With the three mirrors held together, tape is wound around the outside in a spiral.
* 3 The endcap with the eyehole is made by cutting out a circle as large as the outer diameter of the viewing tube from a material that matches or is compatible with the material forming the tube. A concentric, smaller circle is cut out of the end cap, and a piece of plastic is taped or glued to hold it over the opening on the inside of the cap. This hole can be left uncovered, but a clear covering is a good safety precaution to keep any objects from the box or the inside of the tube from falling into the viewer's eye. Acrylic, mylar, acetate, or an optical lense can be used for the peephole. The endcap can then be carefully glued or taped to the end of the tube; in more elaborate designs, these are formally made into fittings that can be screwed on or specially mounted to the tube.
* 4 With the viewing end now closed, the maker slides the assembled set of mirrors into the tube. If the triangle of mirrors rattles



Differing angles of the mirrors create different views through the kaleidoscope.

in the tube, it is taken out, and paper, fabric, or other protective material is wrapped around the outside of the mirrors until they fit securely. Plastic styrofoam "popcorn" or pieces of paper can be pushed down alongside the mirrors to secure them, but they are likely to be off center, which, again will skew the image. The mirrors are pushed in to abut the endcap and to leave space at the other end of the tube for the object box.

* 5 The drawing of the inner diameter of the tube that was made previously van now be used to make plastic pieces for the two ends of the object box. A circle of clear plastic is cut out and inserted in the tube to fit against the ends of the mirrors; it must fit so that it is perpendicular to the tube walls. The distance between this piece of plastic and the open end of the tube is the thickness of the chamber. After measuring this thickness, the maker cuts a piece of cardboard that is as wide as the chamber thickness and as long as the inner circumference of the tube. The maker softens the cardboard by working it between the fingers so it can be wound around the inside of the tube. It should be tested to fit smoothly, then taken out, glued, and affixed in the tube. This cardboard piece holds the inner plastic end of the object box in place, and it also smooths out any gaps in that plastic piece so they can't be seen. The outer plastic circle is then cut. This may also be made of clear plastic or it can be sandpapered to make the surface translucent. If it is left clear or transparent, part of the outside world will show through the object case. A translucent finish will blur the incoming light (and its image) so the inner beads are the objects in focus.
* 6 The kaleidoscope maker can now begin adding beads or other materials to the object case. As the descriptions above suggest, almost any colorful items can be chosen as the objects. The maker adds beads or objects to the case and peeks through the viewing end to check the color balance. When the right combination of objects is selected, the frosted end circle is taped or glued in place. For this simple kaleidoscope, the object case is not twisted relative to the viewing tube. Instead, the whole tube is rotated to change the images.

**Byproducts/Waste**

Kaleidoscope-making generates little waste. The manufactured versions are made to strict specifications so tubes and mirrors are cut to those standards. Some materials (particularly plastics) can be reground if they are faulty and recycled. Some wastage occurs in the beads and items used for the object cases. A company like C. Bennett Scopes, Inc., takes spare beads to schools for use in art projects. The majority of waste at a kaleidoscope factory comes from packing boxes that are also recycled.

**Quality Control**

Safety for employees is a critical issue. If plastics or acrylics are used, acrylic solvents are necessary, and adequate ventilation must be provided around each worker in accordance with regulations by the Occupational Health and Safety Administration (OSHA) and the Environmental Protection Agency (EPA), both Federal agencies. Other safety issues involve equipment mechanics; band-saws may be used particularly to cut parts for prototypes, and a sonic welder that is noisy and is used to seal liquid chambers is operated inside a box insulator. Plastic and lengths of mirror have sharp edges, and care needs to be taken in handling them.

Regulations concerning the quality of the mirrors and lenses are also checked. The lens must be firmly attached to guarantee that no objects are able to fall into the eye. Also chips or fractures in the mirrors must be replaced with new materials. The object box is also checked to make sure that any ampules are not leaking.

**The Future**

In the early 1970s, kaleidoscopes experienced a rebirth in interest that then had smaller peaks and valleys in the following 30 years. In the twenty-first century, kaleidoscopes seem to have a well-established following as an art form, potential gifts, and objects of curiosity for children of all ages. Conventions held by the Brewster Society are an excellent measure of the kaleidoscope's well-being; over 30 shops, countries including Japan and Switzerland, and hundreds of manufacturers and aficionados meet annually to support Sir David Brewster's invention and exchange ideas. Society members, like other hobbyists and enthusiasts, firmly believe in the infinite variations that are possible in the kaleidoscope which they call "candy for the eye."

**Where to Learn More**

***Books***

Baker, Cozy. *Through the Kaleidoscope… And Beyond.* Annapolis, MD: Beechcliff Books, 1987.

Baker, Cozy, and Sara Macfarland. *Kaleidoscopes: Wonders of Wonder.* Concord, CA: C & T Publishing, 1999.

Bennett, Carolyn, and Jack Romig. *Kaleidoscopes.* New York: Workman Publishing, 1994.

Boswell, Thom, ed. *The Kaleidoscope Book: A Spectrum of Spectacular Scopes to Make.* New York: Sterling Publishing Company, Inc., 1992.

Newlin, Gary. *Simple Kaleidoscopes: 24 Spectacular Scopes to Make. New* York: Sterling Publishing Company, 1996.

***Periodicals***

Andrews, Jeanmarie. "The Kaleidoscope." *Early American Homes* 28, no. 6 (December 1997): 35.

Kripalani, Manjeet. "A Rather Strange Object." *Forbes* 150, no. 13, (December 7, 1992): 232.

Novak, William. "Confessions of a Kaleidoscope Collector." *Forbes* (May 17, 1999): 348.

***Other***

The Brewster Society. P.O. Box 1073, Bethesda, MD 20817. <http://www.kaleido.com/brewster.htm>.

C. Bennett Scopes, Inc. 609 West State Street Media, PA 19063. (800) 272-6737. info@cbennettscopes.com. [http://www.cbennettscopes.com](http://www.cbennettscopes.com/) .

— *Gillian S. Holmes*

<http://www.madehow.com/Volume-6/Kaleidoscope.html>

**Be Dazzled: Kaleidoscope**

**Be Dazzled—Make Your Own Kaleidoscope**

 http://kids.nationalgeographic.com/kids/activities/funscience/be-dazzled/

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **YOU WILL NEED**   * Paper towel tube cut eight inches (20 centimeters) long * Clear plastic report cover * Ruler * Pen or marker * Paring knife or art utility knife * Four-inch (ten-centimeter) squares (one each) of black construction paper, plastic wrap, and waxed paper * Scissors * Rubber band * Clear tape * Colored transparent beads, small sequins, and shiny confetti * Stickers and wrapping paper   **HERE’S HOW**   1. Draw an 8-by-4-inch (20-by-10-centimeter) rectangle on the report cover. Cut it out. Draw three lines across the rectangle as shown. 2. Fold the plastic along the lines to form a triangular shape. The quarter-inch (.6-centimeter) strip goes on the outside. Tape the strip along the edge so it stays closed. 3. Slide the plastic triangle into the paper towel roll. 4. Turn the paper towel tube on one end. Trace a circle around it on the construction paper. Poke a hole through the center of the circle and tape it over one end of the tube. 5. Place a square of plastic wrap on the other end of the tube. Press down to create a pouch in the end of the plastic triangle. Put some beads, sequins, and confetti in the pouch. 6. Place a square of waxed paper over the pouch. Stretch the rubber band over both the waxed paper and the plastic wrap. Be sure it’s on tight so nothing spills out! Trim the corners of the squares. Decorate the outside of the paper towel roll with stickers or wrapping paper. 7. Hold the tube up to one eye and look through it. Turn it and watch your own light show!   **WHY?**    Light travels in a straight line through empty space, but when it bumps into an object, it changes direction. Some shiny surfaces, like the plastic report cover or a mirror, send or reflect light back to you. (Think of a ball bouncing off a wall.) The sides of the plastic tube inside the kaleidoscope reflect the beads, sequins, and confetti. The reflections bounce back and forth from side to side creating multiple images. When you turn the kaleidoscope, the pieces move, and you see a different design.    Text by Laura Daily  Illustrations by David Bamundo | |  | | --- | | Illustration: a sheet of plastic with measurements | | **Step 1** | | Illustration: hands folding a sheet of plastic | | **Step 2** | | Illustration: hands holding a folded plastic sheet and paper towel roll | | **Step 3** | | Illustration: a hand holding a pencil and a hand taping paper to a paper towel roll | | **Step 4** | | Illustration: fingers, small objects, and plastic wrap | | **Step 5** | | Illustration: a hand holding waxed paper and a hand holding a rubber band | | Illustration: a hand holding a paper towel roll and scissors | | **Step 6** | | Illustration: a kaleidoscope | | **Step 7** | | Illustration: a boy looking into a kaleidoscope | | **Enjoy your kaleidoscope.** | |

**Kaleidoscope**

The kaleidoscope was invented by Sir David Brewster around 1816 and patented the following year. The device uses the image-forming properties of combined inclined mirrors. Depending on the number of mirrors and the angle between them, the kaleidoscope will produce multiple symmetrical patterns. Since its introduction, the kaleidoscope has been sold primarily as a toy, but has practical uses as well.

A simple kaleidoscope is made of two thin, wedge-shaped mirror strips touching along a common edge or a single sheet of bright aluminum bent to an angle of 45 or 60 degrees. The mirrors are enclosed in a tube with a viewing eyehole at one end. At the other end is a thin, flat box that can be rotated. This flat box is made from two glass disks, the outer one ground to act as a diffusing screen. In this box are pieces of colored glass or beads. When the box is turned or tapped, the objects inside tumble into different groups and when the diffusing screen is illuminated by natural or artificial light, six or eight different symmetrical images appear. The number of combinations and patterns is without limit.

There are five different types of kaleidoscopes. The chamber kaleidoscope has an enclosed object case with free-tumbling jewels, glass, beads or other objects. The liquid chamberscope has an object case filled with liquid (usually glycerin) in which the jewels, glass beads, or other objects float. The wheel scope has one or more wheels at its objective end that may contain glass, translucent rocks like agates, pressed flowers, beads, jewels, or other objects. The refillable scope features a removable object chamber. The contents of this chamber can be changed and users can experiment with their own assortment of colors and objects. The teleidoscope uses mirrors and lenses alone so that anything that is viewed, is multiplied.

http://micro.magnet.fsu.edu/optics/activities/students/scopes.html

**Make a Pringles Can Kaleidoscope**

Design your own kaleidoscope out of a Pringles can with the following directions.

**Required Materials**

* Pringles can
* Nail and hammer
* Scissors and compass
* Transparency film
* Black construction paper
* File folder
* Glue
* Pen and ruler

**Activity Directions**

1. Make a hole in the center of the metal bottom of the Pringles can with the hammer and nail. With the point of the scissors or other object, expand the hole to a 1.5 cm diameter. This will be the eyehole of the kaleidoscope so it is important that there are no sharp edges.
2. Cut out a 4 cm square of transparency film. Glue the transparency square over the eyehole of the kaleidoscope.
3. Cut from the file folder three 7.5 cm x 19.5 cm strips. Do the same with the black construction paper and the transparency film.
4. Glue the strips together in the following order: file folder, black construction paper, and then transparency film. You should now have 3 sets of layered strips. The transparency on top of the black paper should provide a mirror-like surface.
5. Place each set of strips into the open end of the can, edge to edge, with the mirror surfaces facing the center of the can. Looking into the can, the top edges of the strips should form an equilateral triangle.
6. Cut 2 strips from the file folder (23 cm x 1.5 cm). Fold one strip in half the long way. Glue the folded strip along the long edge of the unfolded strip.
7. Glue the combined strips around and along the inside edge of the open end of the can above the mirrors. The folded strip should be closest to the mirrors. Let the glue dry.
8. Cut a circle of transparency film with a diameter of 7.5 cm (the same diameter as the opening of the can).
9. Place the transparency circle inside the open end of the can with its edge against ledge created by the folded strip. Glue the circle in place with rubber cement.
10. Place various objects (beads, shells, gemstones, etc.) on top of the transparency circle. Place lid of can back on.
11. Your kaleidoscope is done! Look through the eyehole while turning the can and see the kaleidoscopic show.

http://micro.magnet.fsu.edu/optics/activities/students/scopes.html

**Make a Paper Towel Roll Kaleidoscope**

Design your own kaleidoscope out of a paper towel roll with the following directions.

**Required Materials**

* Paper towel roll
* Scissors and compass
* Masking tape and glue
* Pen and ruler
* Black construction paper
* Transparency film
* File folder

**Activity Directions**

1. Trace the top of the paper towel roll on the folder. Using a compass, draw a circle 1.5 cm larger around the circle you traced. Cut out the larger circle.
2. Make a hole about 1.5 cm in diameter in the center of the circle. This will be the eyehole for the kaleidoscope.
3. Make small cuts around the outer edge of circle from the edge to the traced line. The cuts should be made about every 1.5 cm around the circle. The cuts will form little tabs around the edge of the circle.
4. Cut out a piece of transparency film large enough to cover the eyehole. Glue it over the eyehole.
5. Place the circle on the one end of the roll with the transparency piece facing inside the roll. Fold down the tabs all around the outside of the roll. Secure it to the roll with masking tape.
6. Cut from the file folder three 6.5 cm x 27 cm strips. Do the same with the black construction paper and the transparency film.
7. Glue the strips together in the following order: file folder, black construction paper, and then transparency. You should now have 3 sets of layered strips. The transparency film on top of the black paper will provide a mirror-like surface.
8. Place the strips side-by-side, mirrored surface down, on top of your work surface. Put masking tape across the strips at the top and bottom.
9. Fold the connected strips to form a three-sided column 27 cm long with the mirrored surface facing inside. Tape around the column to hold it together. Looking into the column, the top edges of the strips should form an equilateral triangle. Place the column into the open end of the tube.
10. Cut out two circles from the transparency film using the directions in steps 1 and 4. You should now have two circles of transparency film with 1.5 cm tabs around it.
11. Fold back the tabs of one of the transparency circles then place it into the open end of the tube so the circle is touching the mirrored column and the tabs are facing out. Secure the circle to the tube with tape.
12. Place your choice of colorful objects (beads, gems, rocks, etc.) into the open end of the tube.
13. Now place the other transparency circle over the open end of the tube. Fold down the tabs all around the outside of the roll. Secure it to the roll with masking tape.
14. Your kaleidoscope is done! Look through the eyehole while turning the tube and see the kaleidoscopic show.

http://micro.magnet.fsu.edu/optics/activities/students/scopes.html