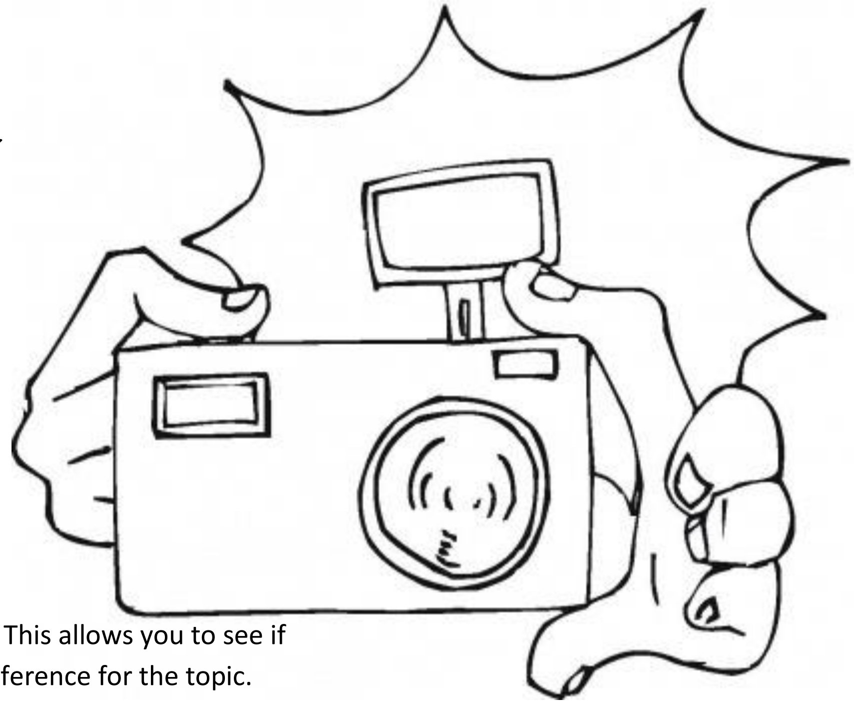
Click!



Accessing Prior Knowledge:

Write key vocabulary words chosen from the lesson on the board (sheet of paper, or overhead, etc) and based on the words, ask the students to try and determine the focus of the lesson. This allows you to see if your students have any frame of reference for the topic.

And/Or: Introduce the topic with an interesting picture book related to cameras and how they capture our imaginations, like the magical photographs and the science minded boy in *Flotsam* or the find the fascinating *Camera Obscura* by Abelardo Morell and Luc Sante at your local library; or delve into inventors and inventions (and engineers) and show how early technological accomplishments made today's technology possible, using a attention grabbing book like *Timeless Thomas* [about Thomas Edison] or *Neo Leo* [about Leonardo daVinci, artist, inventor, engineer, and scientist] both by Gene Barretta.

After reading, ask students to share their own experiences, hunches, and ideas about cameras and inventions [go back to the book for suggestions] and have them relate and connect it to their own lives. Sometimes you may have to offer hints and suggestions, leading them to the connections a bit, but once they get there, they will grasp it for themselves.

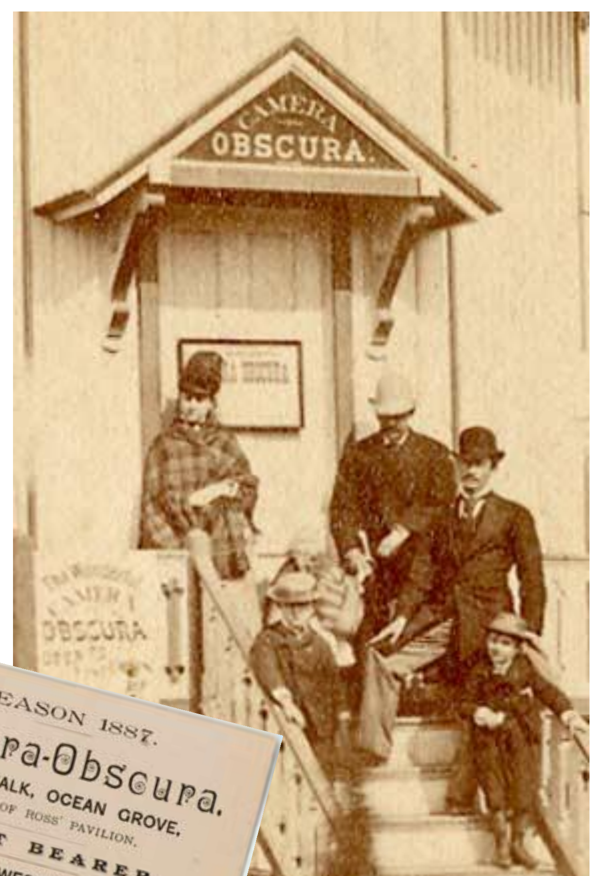


Image credit: http://brightbytes.com/cosite/lost_us_beach.html.

Bravura Camera Obscura!

Have your students brainstorm ideas of how a camera works? What are their ideas of how they were first designed? Ask them if they knew the first cameras took up an entire room?

Something strange and wonderful happens when a beam of light enters a dark space through a tiny opening. **What do students think happens?** The principle was known to ancient Chinese and to ancient Greeks such as Aristotle more than 2,000 years ago. Aristotle described the phenomenon (a fact or situation that is observed to exist or happen with the five senses, esp. one whose cause is in question.) back in the fourth century B.C [400-300 BC]. and questioned why the sun could make a circular image when it shined through a square hole (more about that later). Leonardo deVinci in Renaissance Italy sketched the process. In Coney Island and other 19th-century seaside resorts, tourists lined up to see the magical results.

The first camera obscuras were small rooms that were completely dark except for a tiny hole in a wall that let in a dot of sunlight. **What do the students think people saw?** People in the room saw an image of the trees and sky on the wall opposite the hole-and were amazed when the image disappeared at sunset! **Why would it disappear?**

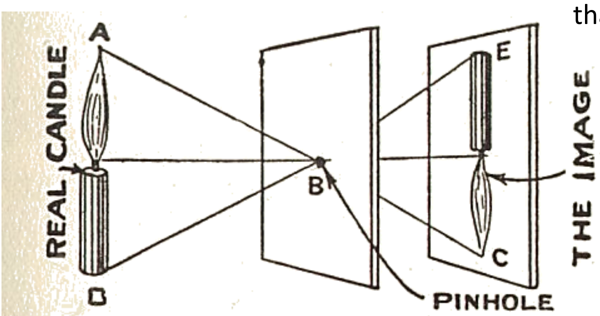


FIG. 131.—How Light and a Pinhole Form an Image.

The camera obscura was the predecessor of (came before) the photographic camera, but without the light-sensitive film or plate to capture the image from the light. **What would you have to do to capture the picture then?** Ex. trace it, draw it, etc. The term 'camera obscura' means 'dark chamber', because the instrument up until the 16th century typically took the form of a closed room, the windows shuttered, with a small hole in a blind or door. So, when we break it down, a camera in its simplest form, is a small hole (aperture) through which light passes from an object outside into a dark chamber, or room. The image appears upside down on the wall opposite the hole.

A Room with a View

If you need help with how, watch as National Geographic magazine staffers demonstrate how to create your own room-size camera obscura at http://ngm.nationalgeographic.com/2011/05/camera-obscura/camera-obscura-video.

Cover the classroom windows with black plastic, making the space as dark as a cave, cut a dime-size hole in the material, and tell your students to watch. After letting their eyes adjust to the dark, the students should see upside-down and reversed images in moving color of the scene outside will

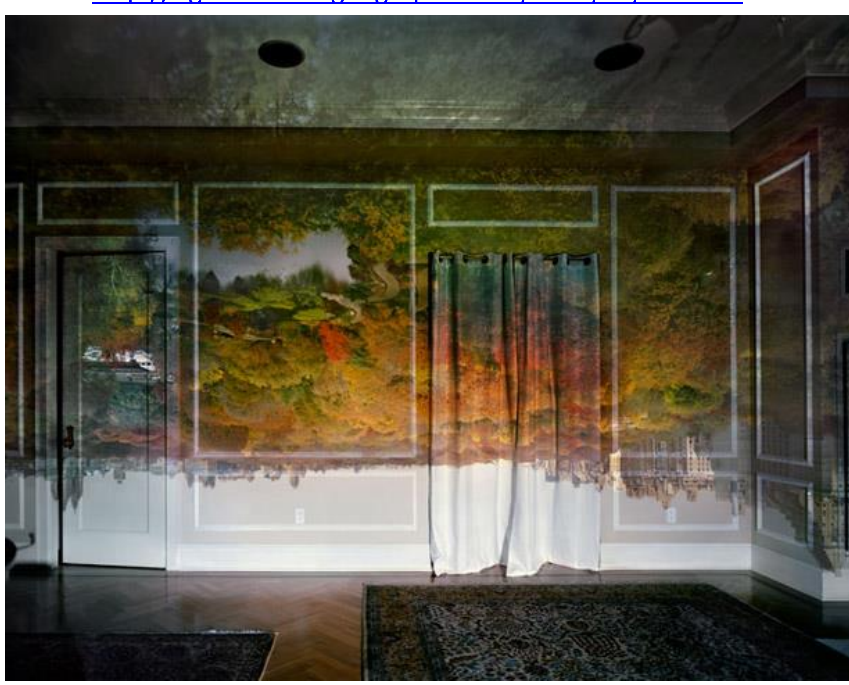


Image Credit: Abelardo Morell. http://ngm.nationalgeographic.com/2011/05/camera-obscura/oneill-text appear on a piece of paper or canvas held or taped opposite the hole*. Note: If the walls are painted a dark shade or the image is not bright enough, place a portable projection screen or a large sheet of white paper opposite your pinhole*. The wall comes alive like a movie screen, its surface covered with a fuzzy image of people and cars moving along outside. Then the double take: The image will be upside down, sky on floor, ground on ceiling, the laws of gravity seemingly gone haywire.

The classroom is transformed into a camera obscura, a dark chamber, the Latin name for perhaps the earliest known imaging device and the ancestor of the photographic camera. Now, experiment with different sizes of holes and see the effect on the image.

Explaining the optical principle behind the device is probably the most complicated thing about it. A camera obscura receives images just like the human eye—through a small opening and upside down. Light from outside enters the hole at an angle, the rays reflected from tops of objects, like trees, coursing downward, and those from the lower plane, say flowers, traveling upward, the rays crossing inside the dark space and forming an inverted image. It seems like a miracle, or a hustler's trick, but it's simple physics. The brain automatically rights the eye's image; in a regular camera a mirror flips the image.

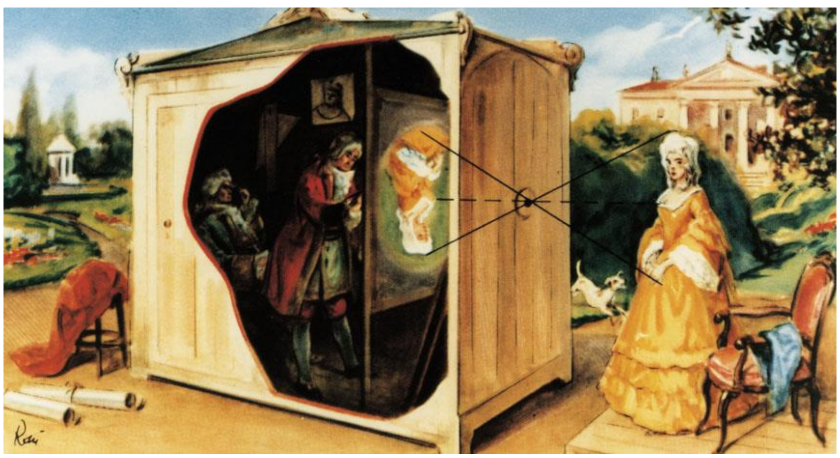
Options:

- Place a simple convex lens against the pinhole. Enlarge the aperture so you have a camera with a lens.
- Place a digital camera on a tripod aimed at the canvas, and after a few minutes, depending upon the amount of sunlight shining on the subjects, capture images from the camera obscura.

Have students look at/explore the galleries of Photographer Abelardo Morell's camera obscura images @ http://ngm.nationalgeographic.com/2011/05/camera-obscura/morell-photography and http://www.abelardomorell.net/photography/cameraobsc_01/cameraobsc_01.html.

Let in a Little Light

In the first designs light entering the room through the hole then cast an image onto a translucent screen or onto the wall opposite the door. *Translucent means allowing light to pass through but not showing the distinct images on the other side like transparent glass*



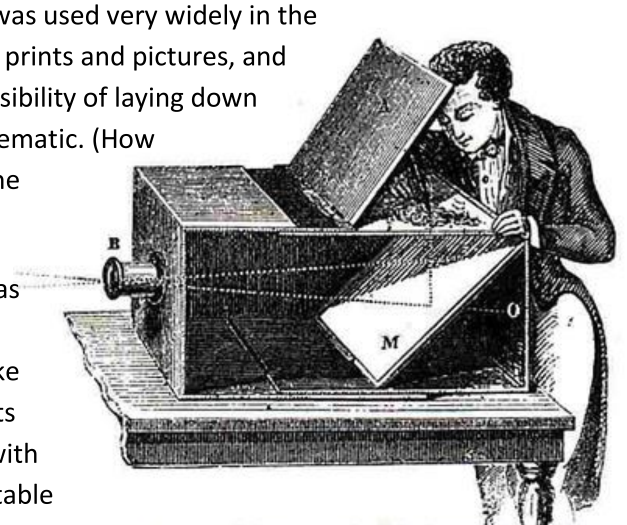
would. In the screen design the image is projected onto a translucent screen, made perhaps of oiled paper or ground glass, and the artist looks at it on the far side of the screen, away from the scene - an arrangement first suggested by Leonardo da Vinci. This has the advantage that the user does not get in the way of the light.

The size of the hole will affect the sharpness of focus and the brightness of the image. One problem is that the image in such a 'pinhole' camera, even of a sunlit summer landscape, can be very dim. The one object that is clearly visible is the sun itself. Indeed this remained the only real application of the camera up until the 1550s: for astronomers to make solar observations without damaging their eyes. The first published illustration of a camera (of this or any type), is in a book from 1545, by the Dutch mathematician and astronomer Gemma Frisius. It shows an eclipse observed by Gemma Frisius at Louvain in the previous year.

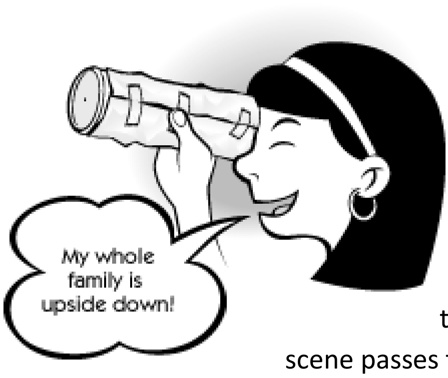
The situation changed in the mid-16th century, when it occurred to a number of people, it seems simultaneously, to substitute glass lenses for simple pinholes. At its simplest, a lens is just a curved piece of glass or plastic. Its job is to take the beams of light bouncing off of an object and redirect them [bends them] so they come together to form a real image -- an image that looks just like the scene in front of the lens, except upside down.

Typically the lenses used back then were convex lenses of the kind then in wide use for the correction of long sight. Two Venetian authors, for example, give clear descriptions of cameras with convex lenses - Daniele Barbaro in 1568 in a perspective manual for architects and painters, and GB Benedetti in a mathematical text of 1585. These authors describe how to draw from the camera image by tracing outlines onto the paper screen. The instrument was used very widely in the 18th and 19th centuries - before photography - for copying prints and pictures, and for enlarging or reducing them. Others even hint at the possibility of laying down colors over the projected image, although this idea is problematic. (How could you see the colors of your paints in the darkness of the closed room?)

A portable version of the camera obscura—the chamber was now a box, the hole was fitted with a lens—first became popular in the 17th century and was adapted by painters like Johannes Vermeer and Canaletto as a drawing aid. Scientists used it to observe solar eclipses, just as children do today with pinhole cameras made from shoe boxes. Artists used a portable camera obscura like this to trace the images projected onto the ground glass.



Pringles Pinhole



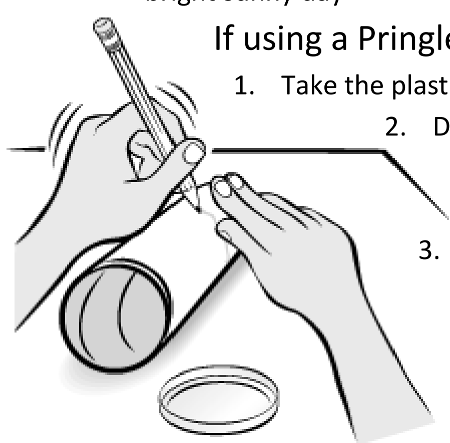
http://www.exploratorium.edu/science_explorer/pringles_pinhole.html © 1998 Exploratorium

A pinhole camera is a simple camera without a lens and with a single small aperture — effectively a light-proof box with a small hole on one side and is just a portable version of this ancient camera obscura. (It's a bit inconvenient to carry a room with you to take pictures of your family vacation!). Light from a scene passes through this single point and projects an inverted image on the opposite side of the box. Students can easily construct this camera themselves using things lying around like match boxes, cardboard tubes, or any kind of boxes, paper, duct tape etc. An empty oatmeal canister works perfectly for this science experiment The small amount of light passing through this pin sized hole produces the image.

Materials:

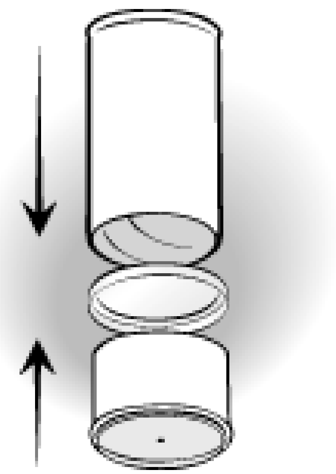
- empty Pringles® chip can works best, but another container, like an empty towel roll will work well too.
- marker
- ruler
- X-Acto knife or utility knife (ask a grown-up to help you cut)
- thumbtack or pushpin
- masking tape
- Black construction paper
- Parchment paper (printer, vellum, or wax paper will also work)
- aluminum foil
- scissors
- Something to poke a hole in the container (A pen, screwdriver, or long nail works great. Make sure there is adult supervision with the sharp objects if you are working with young kids.)
- bright sunny day

If using a Pringles chip can (Student Instructions)

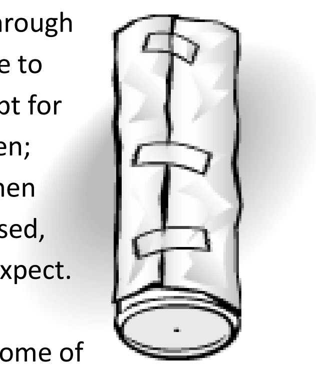


1. Take the plastic lid off the Pringles® can and wipe out the inside. (Save the lid!)
2. Draw a line with the marker all the way around the can, have students measure about 2 inches up from the bottom and then help them cut along that line so the tube is in two pieces.
3. The shorter bottom piece has a metal end. With the thumbtack, make a hole in the center of the metal. This step requires some patience, because you want it to be a tiny, smooth hole. Have students tap the top of the pin with a heavy object, but then turn it as they push it through the metal so that the edges will be smooth. (If they are using a paper towel tube instead of a chip

can, place a piece of aluminum foil between two index cards and gently turn the pin through the layers. Then tape the aluminum foil to the end of the tube, with the hole in the center.)



4. We're going to use the plastic lid as a screen. If your lid is perfectly clear, you may need to apply a piece of wax paper, white tissue paper, or vellum to the lid to act as a translucent screen. Put the plastic lid onto the shorter piece. Put the longer piece back on top. Tape all the pieces together.
5. To keep light out of the tube, have students measure out and use a piece of aluminum foil that's about 1 foot long. Tape one end of the foil to the tube. Wrap the foil all the way around the tube twice, then tape the loose edge of the foil closed. If you have extra foil at the top, just tuck it neatly inside the tube.
6. Roll the piece of black construction paper into a tube and insert it part-way into the open end of the can. This will act as a light-shielding eyepiece for your camera.
7. Go outside on a sunny day. Close one eye and hold the tube up to your other eye. You want the inside of the tube to be as dark as possible-so cup your hands around the opening of the tube if you need to. Look around your yard through the tube. The lid makes a screen that shows you upside-down color pictures!
8. Or, if it’s not sunny out, place an object such as a flower or pencil (or even your hand!) under a bright lamp so it is well lit. Point the pinhole end of the camera at it and look through the black paper eyepiece. (You may need to cup your hand around the eyepiece to help keep the inside of the can dark. This will be easier if the room is dark except for the lamp.) You should see a color image of the object on the waxed paper screen; move your camera in and out until the object is in focus. Don't get confused when trying to center the object in your viewer! The image is upside-down and reversed, so you will have to move the camera in the opposite direction from what you expect. Remember, practice makes perfect!



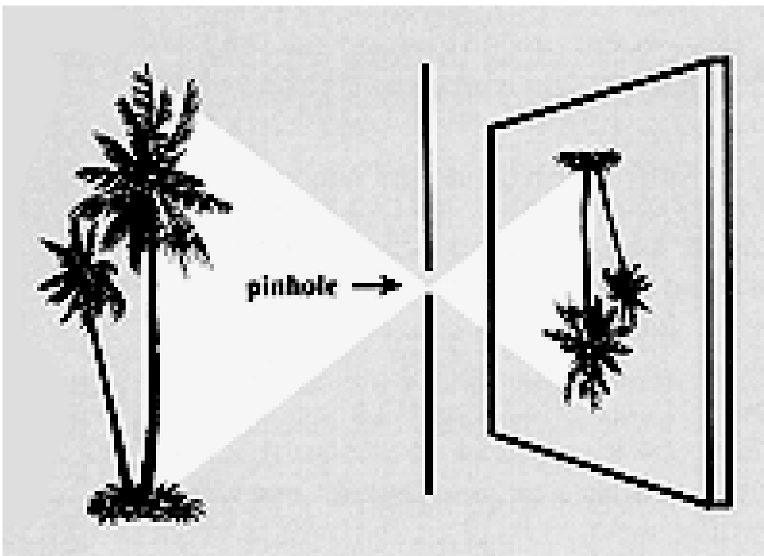
9. Think about what you could do to improve your pinhole camera, and then try some of your ideas. Ex. What if you used a foam soda can holder as an eyepiece? It makes the inside of the tube dark, and is easier to use for people who wear glasses. What would happen if the screen were farther away from the pinhole? What other kinds of materials would work for the screen? Would a bigger hole make a better image?
10. Hold your hand below the tube and move it very slowly upward. Your hand is moving up, but you'll see its shadow move down the screen! You've made a camera!

Have students experiment, if they make the hole bigger what happens? [The image will get brighter, but also more blurry.] If you make more than one hole in the bottom of the box what will happen? [You'll get more than one image.]

What's going on? Upside Down & Backwards

How does a pinhole let you see the images carried by light? And why are these images upside-down and backward? A pinhole camera works in much the same way as your eyes, and the eyes of many other animals and insects.

The simplest way to understand pinhole images (and your eyes) is to take a look at what happens to

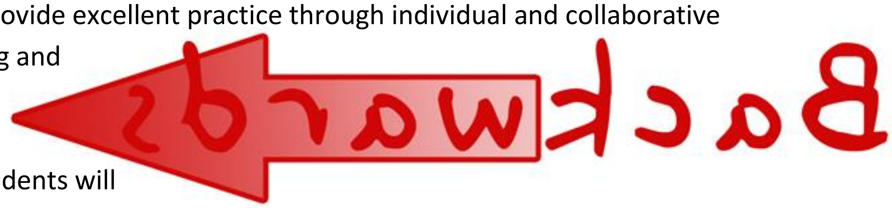


light rays reflecting from an object say a tree that you are looking at with your pinhole viewer. Sunlight bounces off the leaves, the trunk, the ground beneath the tree. A pinhole lets through only a portion of these reflected light rays. Most of the light that reflects from the tree is blocked bv the cardboard surrounding the pinhole. Only a few of the rays of light that bounce off a particular leaf are heading in just the right direction to shine through the pinhole of your viewer. Light rays from leaves at the top of the tree must slope down at a steeper angle to pass through the pinhole. These rays hit the bottom of the screen. Rays of light from the base of the tree trunk must slope up to pass through the pinhole. These upward moving rays will hit the top of the screen. Think about this: if the rays from the top of the tree hit the bottom of the screen, and the rays from the bottom of the tree hit the top of the screen, then seems like you should see an upside-down picture of the tree on your screen. (And you do!) The same logic applies to right and left so that the image is also reversed this way.

The tree has more points than the top and bottom. The same rules apply to light rays reflecting from every point on the tree's leaves and trunk: only the light rays that are heading in just the right direction will pass through the pinhole. On the other side, these rays of light line up geometrically to make an upside-down and backward image of the tree.

Backwards Math: Covering the Basics

Just like in a camera math can be flipped upside down and backwards from the way we normally see it and do it. The following activities provide excellent practice through individual and collaborative activities that stress problem solving and critical thinking, ex. as applied to order of operations and math problems. Classes and groups of students will



be challenged to work together to explore and complete the tasks.

These activities will also give you an opportunity to introduce and practice the order of operations:
a. Do work inside **parentheses**.
b. Solve **exponents**.
c. **Multiply** and **divide** from left to right in the problem.
d. **Add** and **subtract** from left to right.

An easy acronym to help remember the order of operations is P.E.M.D.A.S.: "**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally."

Materials:

- paper
- calculators
- printouts
- pencils
- butcher paper

Tell the students that today's math will be backwards. You will give them all the answers. (This will usually make them pretty happy.) However, tell them that they must come up with the correct problem to the answer.

Variations:

1. Younger students may be given a limited range of numbers, ex. 1-10, as solutions. Students must come up with as many problems as they can that correctly have those numbers as their solutions within a limited amount of time, ex. 60 seconds. Students must use each of the required grade level appropriate skills within their problems at some point, ex. multiplication, division, subtraction, addition.
2. Have students do as many problems as they can with a specific number, ex. 10, as the second number in the problem, using their grade level appropriate skills, ex. multiplication, division, subtraction, addition, within a specific time period, ex. 3 minutes. Note which areas your students struggle with and continue practicing basic skills and build upon those and go deeper as their skills go.
3. Give students part of the answer, ex. the answer must be a two digit answer, ending in 5. Students must come up with as many problems as they can that correctly have that numbers as the second number in their solutions, ex. 35, 25, 75, 150, within a limited amount of time, ex. 60 seconds. Students must use each of the required grade level appropriate skills the teacher declares, ex. multiplication, division, subtraction, addition.
4. Draw a grid like the following on the board and give the students two or three minutes to write as many addition and subtraction, multiplication, or division equations as they can based around the included digits [the following numbers may be changed, the grid is a sample].

15	9	6	7
3	12	8	5
7	4	13	2
5	1	11	10

The numbers in the equation must be connected vertically, horizontally, or diagonally. For example, with this grid these are acceptable: 15 – 12 = 3, 5 + 7 = 12 (but not 7 + 5 = 12), 15 – 3 – 7 = 5. Equations must involve two or more numbers, and one or more operations, but no number can be used twice.

Scoring: After time is called, have players take turns (in a clockwise circle) reading the problems they wrote down for each solution. If another player or players have the same math problems everyone must cross it out, only unique math problems get points. If a player reads off a problem that another player thinks is incorrect, you can either use a calculator as the deciding factor, or all players can vote on it. If it’s decided it’s not a valid problem, then the player who read it must subtract a point. There is no penalty for writing down an invalid problem (no other players have to subtract points if they have it written down), there’s only a penalty if they decide to read it out loud during the scoring period.

Students gain points for each equation only they have recorded. One point is given for each number used in the equation, for example, 15 – 3 – 7 = 4 + 1 earns five points! The player with the most points wins.

Once all players read their problems, they announce their scores to the group. Backwards Math can either be played round by round (ie. there's an individual winner for each round separate from other rounds), or a cumulative score can be kept to have one overall winner at the end of the game.

Option: For easy assessment, have students work in teams. One partner verifies the solution of another student. If they believe it’s correct, they record it on the chart. If another team proves them wrong, that team gets two points and the incorrect solution is erased.

Backwards Math: Four 4s Challenge

Simply Great Math Activities: Number Sense ©Teacher to Teacher Press Fulton and Lombard

$$1 = {}^{4}/_{4} \bullet {}^{4}/_{4}$$
$$1 = {}^{4}/_{4} \div {}^{4}/_{4}$$
$$1 = {}^{4}/_{4} + (4 - 4)$$
$$1 = {}^{4}/_{4} + (.4 - .4)$$
$$1 = {}^{44}/_{44}$$
$$1 = 44^{(4-4)}$$
$$1 = {}^{4}/_{4} \bullet {}^{.4}/_{.4}$$
$$1 = (\sqrt{4}+4) \div (\sqrt{4}+4)$$
$$1 = {}^{4.4}/_{4.4}$$
$$1 = {}^{(4.4 - .4)}/_{4}$$

The graphic on the right shows 10 different ways to use four 4's to create expressions equaling one. In them we see parentheses, place value, decimals, square roots, exponents, and more. Factorials and the greatest integer function could also be used to give students a richer experience.

- 1 = 4/4+(4-4)
- 2 = 4/4 + 4/4
- 3 = (4 + 4 +4)/4
- 4 = 4 + (4-4) × 4
- 5 = (4 × 4 + 4)/4

As students find ways to combine fours, their number sense deepens and their creativity increases. The next step extending this activity might be looking for 10 ways to use four 4's to create expressions equaling two. As students gain confidence in their math skills they are willing to explore new and novel combinations of numbers and their numerical flexibility improves. This is great news for teachers as our students are increasingly required to be able to see and explore algebraic expressions. Give this a try and marvel at the amazing expressions your students will create.

Tip: Have classes compete against one another. Assign fours to one class, fives to another, sixes to the next and so on.

Materials:

- paper
- calculators
- printouts
- pencils
- butcher paper

Again, tell the students that today's math will be backwards. You will give them all the answers. However, tell them that they must come up with the correct problem to the answer, but in this variation, the challenge is, the only numbers they can use are four 4's.

For example, they can make a problem that produces the answer one in either of these ways:

$$\frac{4}{4} x \frac{4}{4} = 1 \qquad\qquad \frac{44}{44} = 1$$

Challenge students to find other ways to make a problem equal to one.

Next have them try to get the numbers two through ten. This will give you an opportunity to introduce the order of operations:

a. Do work inside **parentheses**.

b. Solve **exponents**.

c. **Multiply** and **divide** from left to right in the problem.

d. **Add** and **subtract** from left to right.

For example, in this problem, solving correctly will result in an answer of 32:

$$\frac{4^4}{(4+4)} = \frac{4^4}{8} = \frac{256}{8} = 32$$

An acronym for the order of operations is P.E.M.D.A.S.: "**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally."

For more advanced classes, you can introduce exponents, roots, factorials, and the greatest integer function. Some examples of these are given below.

Exponents	$4^4 = 4x4x4x4 = 256$
Square roots	$\sqrt{4} = 2$
Factorial	$4! = 4x3x2x1 = 24$
Greatest integer function	$[4x4.44] = [17.76] = 17$

(The greatest integer function, [x], is the largest integer $\leq$ to x.)

Have the students number a piece of paper one through one hundred (or whatever range you desire, ex. to 40). Note: people have managed to do this for 1000s of numbers!) Allow students to make up problems and write them on the paper by the correct answers. Share these with the whole class to get them started. Keep a classroom sample chart up on the wall with correct problems for each solution 1-100 as they are found and verified. Students can volunteer solutions to various answers. Write them on the board and have the class verify them. Those that work can stay on the list or chart. You may wish to include multiple solutions to some answers.

You may wish to have students work in teams of three or four. This project will take more than one day. Even advanced students will have difficulty finding all 100 answers in a week. Option: You might prefer to ask them to do ten problems per session.

Discuss with students, if you erased the four 4's in a problem and substituted four 5's, would any of them have the same answer? Why or why not?

Would four 9's be easier or more difficult to use? Why?

How many problems can you write that will have a solution of 1?

Extension: This assignment can be repeated and/or modified using four fives, four sixes, and so on. Some numbers will provide greater difficulty. For example, while 44 is usable in some problems, 88 rarely is since it is too large a number. However,

$$[8^{.8}] \approx [5.2780316] = 5.$$

Note: For those teachers, ONLY, not students, that need a bit of help, some hints may be found here… http://www.wheels.org/math/44s.html and here http://www.mathsisfun.com/puzzles/four-fours-solution.html

Have students brainstorm a creative way of presenting their upside and backwards math/four fours in "photo"/poster format. Have students use materials such as colored poster paper, construction paper, markers, scissors, and other supplies provided to create a neat finished product. You may wish to have the poster size fixed, to limit size. Don't give out the art supplies until they are 3/4 finished with their numbers and have an initial outline of their poster. Students can present their four fours in a variety of ways and allow groups to present their posters to the class.

Backwards Math

Name______________________________

Here are the answers to one hundred math problems. Use four 4's to create problems that will give these answers. Remember to use the correct order of operations to solve your problems: Parentheses, Exponents, Multiply or Divide, Add or Subtract.

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Backwards Math

Name________________________________

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100=______________________________

View It! Find It!

This is another great game for reviewing division problems before a test or quiz. Create a list of division or other math problems and their answers on separate notecards for your own reference. Write the problems on the board, and call out the answers to the class. Have students race to the board to point out the correct problem, with the first student to touch the answer being the winner. For added competition, divide the class into teams and have students take turns being the runner.

Reflective Math

1. The Teacher will have a stack of number cards, with the face cards and ace pulled out leaving the numbers 1-10, and will have the students split into two teams.

2. The Teacher will have the students line up in their teams, with the first person in each line facing the first person in the other line.

3. The Teacher will put a number card on the two students foreheads, the student holding it in place so that they can see the opposing player's card but not their own.

4. The Teacher will then give the solution to a math problem using the two numbers on the cards (addition, subtraction, multiplication) Ex. Student A has 8. Student B has 4. 8x4= 32 so the teacher would say 32.

5. The students must guess what their number is before the other student guesses their own. (In the example Student A must say 8 and Student B must say 4). The student who gets it correct first gains a point for their team.

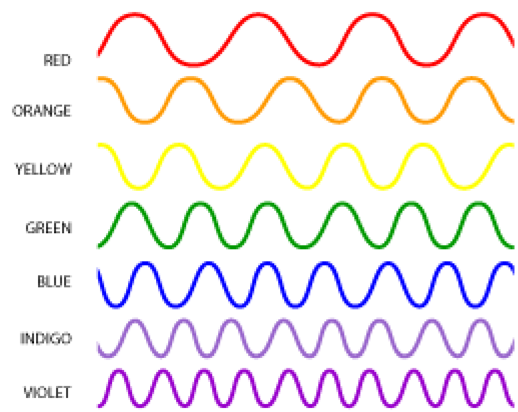
Plain Ol' Boring White Light?

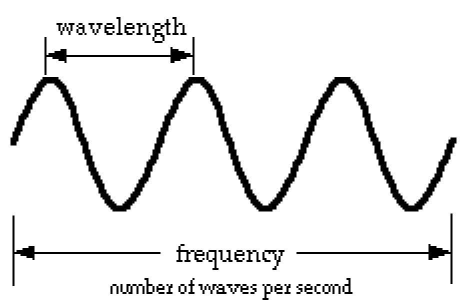
Ask students for their definition of light. Write notes down on the board. The first definition that the dictionary gives is: light is "something that makes things visible or affords illumination," a vague and possibly unsatisfying definition that circles around like a dog chasing its own tail. If you ask a scientist, physicists define light as electromagnetic radiation - a traveling energy wave produced by a vibrating electric charge. Because light has the properties of a wave, we can talk about its wavelength and frequency. The light that our eyes can see – called the visible spectrum - is a narrow band of wavelengths in the huge electromagnetic spectrum, which also includes radio waves, x-rays, ultraviolet light, and infrared radiation.

Light and other electromagnetic radiation moves fast, speeding along at 186,282 miles per second, much too fast for us to perceive its movement. Since we can't see light move, thinking of it as a moving wave can be a little difficult sometimes. And though thinking about light as a wave is extremely useful for some purposes, it's not very helpful if you just want to know why you can't read in the dark.

Let's think about it in another way, and give light a definition that students will probably not find in the dictionary: light is information. **What kind of information might light carry?** This information is rushing past at 186,282 miles per second, ricocheting off the walls, bouncing around like mad, and, sometimes, hitting you squarely in the eye. When you take away light you take away information. **What does that mean?** In a darkened room, you can see little or nothing of your surroundings. Little or no light means little or no information.

Have students consider if you took a color photo of your class. With a camera, film, and a little bit of light, you can take a snapshot that contains a great deal of information: There's a phrase, a picture is worth a thousand words, what does that mean to students? **What thousand words does a picture contain?** [ex. It might take a thousand words to describe everything that is shown in that picture] **What kind of information/words does a picture contain? List students' thoughts on the board or large sheet of paper**. Ex: You can look at the picture and count the students, see what projects are in the room, see if it was day or night outside, determine what color shirt someone wore that day, or who was absent. Where did this information come from? It wasn't on the film or in the camera. The information was in the light.





The dictionary defines an image as "a physical representation of a person, animal, or thing, photographed, painted, sculptured, or otherwise produced." A photograph of your class is a static [stationary or fixed, unchanging] image containing much of the information carried by the light. As we've learned whenever you look at your surroundings, you gather visual images - the light entering each eye makes an image on your eye's retina. Even though you can't see light move, you can directly experience the images it produces.

So, rather than completely defining light as information, we could say that light is images. You may prefer to explain to students that light carries information and makes images, but whichever phrasing you choose it's clear that light, information, and images all go together.

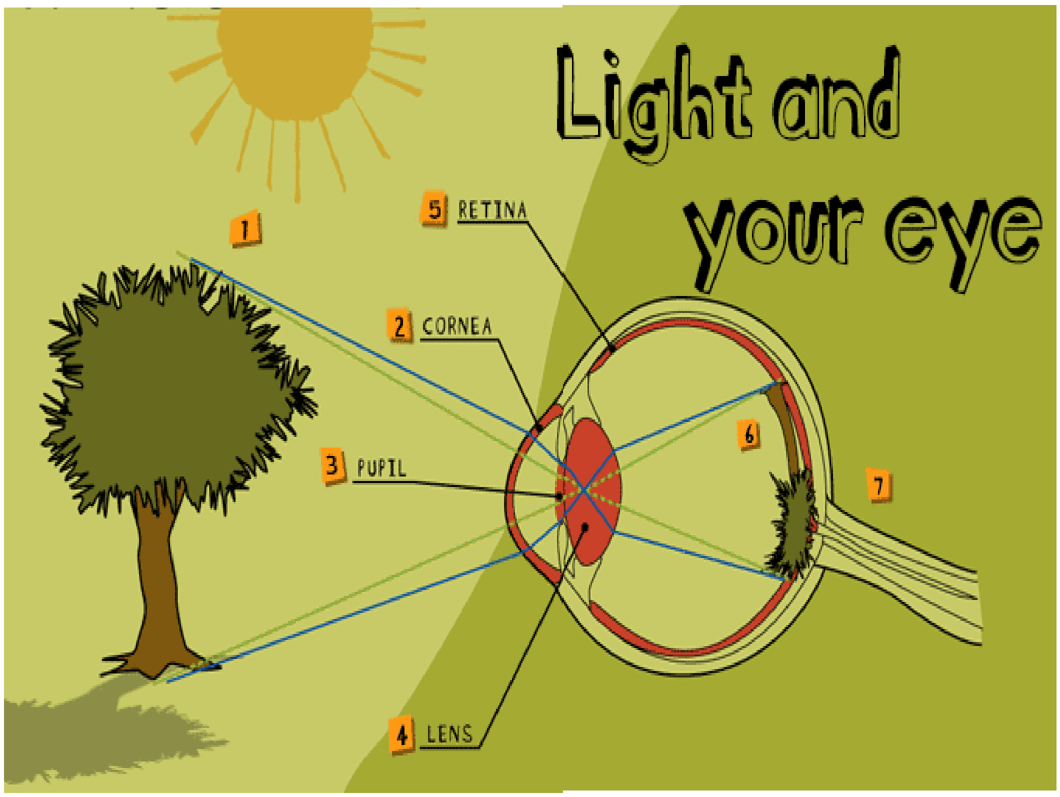
Oh Say, Can You See?

You see the world because light gets into your eyes. Your eye uses that light to make an image of the world inside your eye—just as a camera uses light to make a photograph. Like a camera, your eye also makes upside-down pictures on your retina, but your brain learns to flip the pictures right-side-up without your even thinking about it. Suppose you're looking out the window on a sunny day and you see a tree. You see that tree because light from the sun hit that tree. Some of that light reflected from the tree—it bounced off the tree like a ball bouncing off a wall.

Some of that reflected light hit you right in the eye. That reflected light goes through the clear cornea of your eye. As it goes through the cornea, it bends a little.

The light shines through your pupil, the dark hole in the middle of your eye.

The light shines through the lens of your eye. The lens in your eye bends the light that has reflected from that tree to make a perfect little upside-down picture of the tree on the back of your eyeball.



At the back of your eyeball, there's a layer of cells that are sensitive to light called the retina. When the picture of the tree shines on the retina, the light-sensitive cells send messages to your brain.

Your brain takes the information from your retina and puts it together to make an image of the tree in your mind.

Weird, isn't it? You think you see the tree—but what you see is the light that bounced off the tree and got into your eye. Or if you really want to get picky, what you really see is the fixed-up picture that your brain makes up from the mixed signals it gets from your eye. Amazing!

Diagram it: Have students use the included Eye Sheet and draw the paths of light as they come from the object, through the hole, and onto the screen and follow the path of light through their eye and describe how their eye uses light to make an image.

Student Name: ____________

A tough, clear covering over the iris and the pupil that helps protect the eye. Light bends as it passes through the cornea. This is the first step in making an image on the retina. The cornea begins bending light to make an image; the lens finishes the job.

the dark circle in the center of your iris. It's a hole that lets light into the inner eye. Your is round. A cow's is oval.

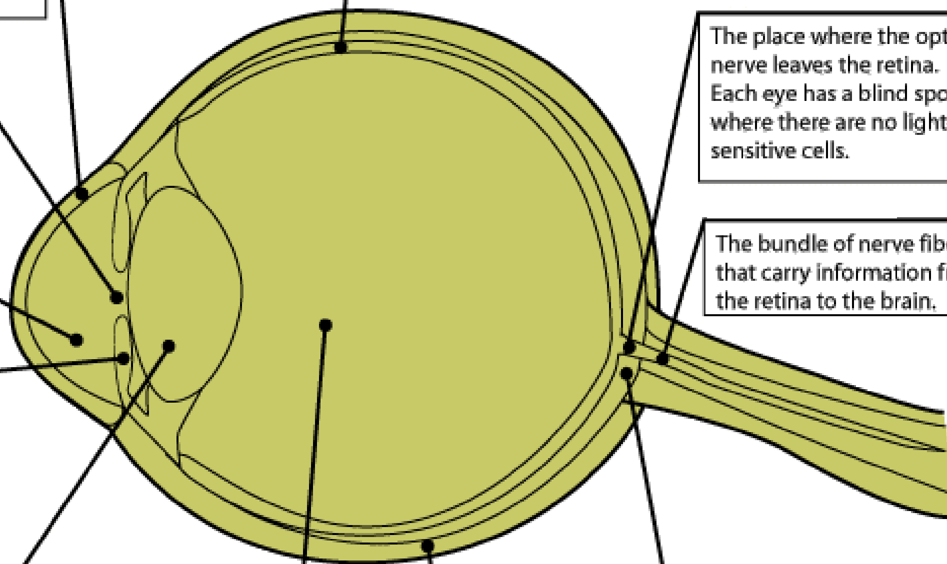
A clear fluid that helps the cornea keep its rounded shape.

A muscle that controls how much light enters the eye. It is suspended between the cornea and the lens. A cow's iris is brown. Human irises come in many colors, including brown, blue, green, and grey.

The layer of light-sensitive cells at the back of the eye. The retina detects images focused by the cornea and the lens. The retina is connected to the brain by the optic nerve.

The place where the optic nerve leaves the retina. Each eye has a blind spot where there are no light-sensitive cells.

The bundle of nerve fibers that carry information from the retina to the brain.



A clear, flexible structure that makes an image on the eye's retina. The is flexible so that it can change shape, focusing on objects that are close up and objects that are far away.

The thick, clear jelly that helps give the eyeball its shape.

The thick, tough, white outer covering of the eyeball.

The colorful, shiny material located behind the retina. Found in animals with good night vision, the reflects light back through the retina.

Match the correct term to the parts of the Eye in the diagram above[each term will only be used once:

- Tapetum
- Vitreous Humor
- Iris
- Pupil
- Cornea
- Retina
- Blind Spot
- Lens
- Sclera
- Optic Nerve
- Vitreous Humor

Draw and label a diagram of the path of light through your eye in this box [or use the back of this paper], and on the back of this sheet draw and label a diagram of how cameras use light to make an image.

Student, in Sight

Step 1: Bring this printed page closer and closer to your eye until you cannot clearly focus on it any longer.

Describe what happened:

____

____

Your pupil is a small hole, does your eye act like a true pinhole camera and focus clearly on nearby objects even when they're really close? What makes you think this?

____

____

Step 2: Poke a single pinhole into a card given to you by your teacher. Hold the card in front of your eye and read these instructions through the pinhole. Bright light on the print may be required. Bring the page closer and closer to your eye [that is still behind the card] until it is a few centimeters away. You should be able to read the type clearly. Then quickly remove the card and see if you can still read the instructions without the benefit of the pinhole.

Enlist the help of people in your group who are nearsighted and who are farsighted (if you're not one of them yourself).

1. A farsighted person without corrective lenses cannot see close-up objects clearly. Can a farsighted person without corrective lenses see close-up objects clearly through a pinhole? Test it and write your conclusions.

____

____

2. A nearsighted person without corrective lenses cannot see far-away object clearly. Can a nearsighted person without corrective lenses see far-away objects clearly through a pinhole? Write your conclusions after testing it.

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3. Why do you think a page of print appears sharper yet dimmer when seen through the pinhole?

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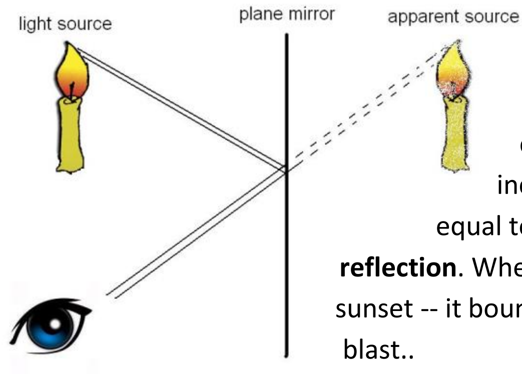
Mirror, Mirror…



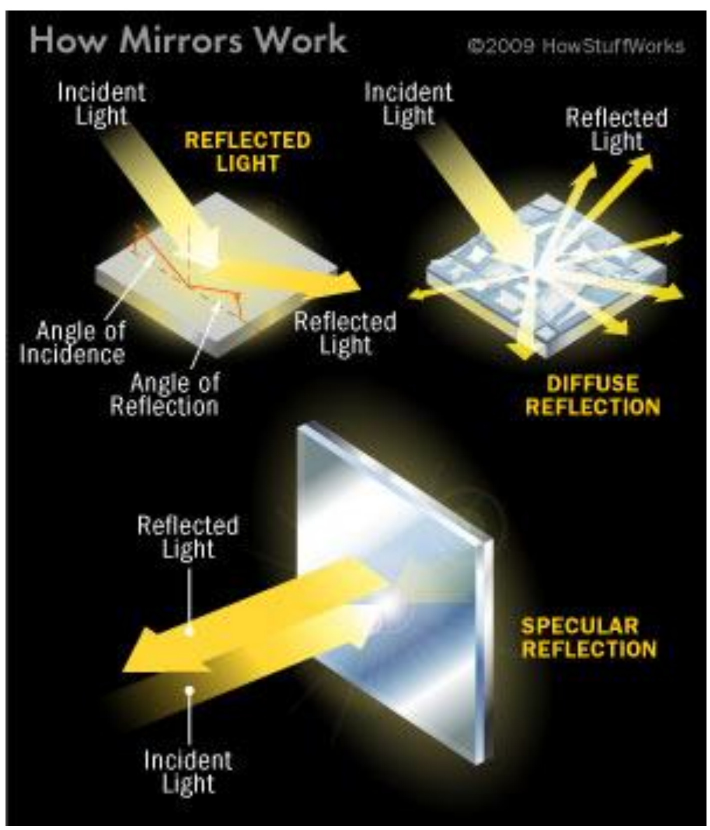
In order to understand mirrors, we first must understand light. The **law of reflection** says that when a ray of light hits a surface, it bounces in a certain way, like a tennis ball thrown against a wall. The incoming angle, called the **angle of incidence**, is always equal to the angle leaving the surface, or the **angle of reflection**. When light hits a surface at a low angle -- like on a lake at sunset -- it bounces off at the same low angle and hits your eyes full blast..

When light strikes a mirror it bounces off. This is called reflection of light. When you look at an object in a mirror, you are seeing the reflection of light from the object. The type of image produced by a flat mirror is called a **virtual image**. Even though light is bouncing off the mirror, our eyes are fooled into thinking it's coming out of the mirror in a straight line. Mirrors are made up of layers of glass. Now usually when light travels it will travel in a straight unless it hits something, BUT when light hits a mirror it bounces or reflects back in the same direction. Mirrors work by reflecting light back to us. Which is why when looking in a mirror it reflects an exact image of what's looking into it except it looks backwards. Option: Allow students a few minutes to experiment with angles and reflected light at http://www.sciencekids.co.nz/gamesactivities/howwesee.html.

So how does this relate to cameras? They use mirrors too! Sometimes.

There are basically two types of film cameras on the market -- SLR (single lens reflex) cameras and "point-and-shoot" cameras. The main difference is how the photographer sees the scene. In a point-and-shoot camera, the viewfinder is a simple window through the body of the camera. You don't see the real image formed by the camera lens, but you get a rough idea of what it is you're pointing the camera at and how the picture might look

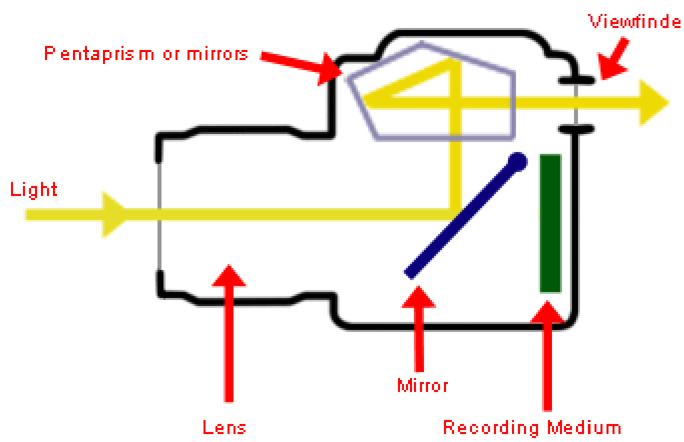
The most popular type of general-purpose camera for enthusiasts and professionals is the single lens reflex (SLR). This type of camera has a moveable mirror behind the lens which reflects an image through a five-sided prism (pentaprism) or pair of mirrors, onto a glass screen (the viewfinder). This

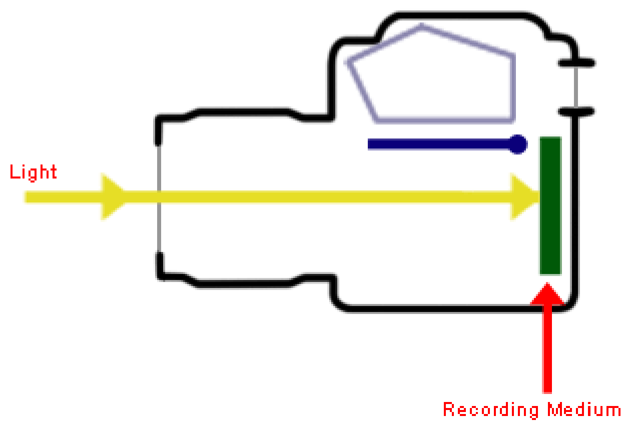


means the photographer sees exactly the same image that will be exposed on the recording medium (film or digital). If you take the lens off of an SLR camera and look inside or take a look the diagram, you'll see how this works.

The camera has a slanted mirror positioned between the shutter and the lens, with a piece of translucent glass and a prism positioned above it. This configuration works like a periscope -- the real image bounces off the lower mirror on to the translucent glass, which serves as a projection screen. The prism's job is to flip the image on the screen, so it appears right side up again, and redirect it on to the viewfinder window so you aren't looking at an upside down image.

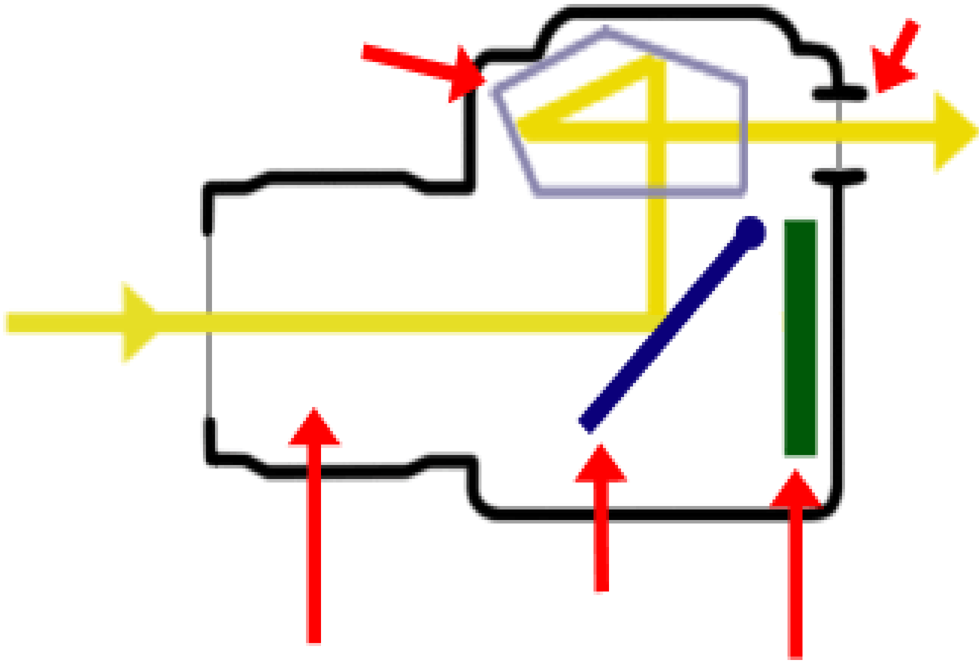
When you click the shutter button, the camera quickly switches the mirror out of the way, so the image/light is directed at the exposed film. When you press the shutter button, the main mirror is flipped out of the way so the light passes straight through to the recording medium as pictured below. As you do this, you notice the image briefly disappear from the viewfinder. There is also the familiar sound of the "camera click" as the whole mechanism works. The mirror is connected to the shutter timer system, so it stays open as long as the shutter is open. This is why the viewfinder is suddenly blacked out when you take a picture.



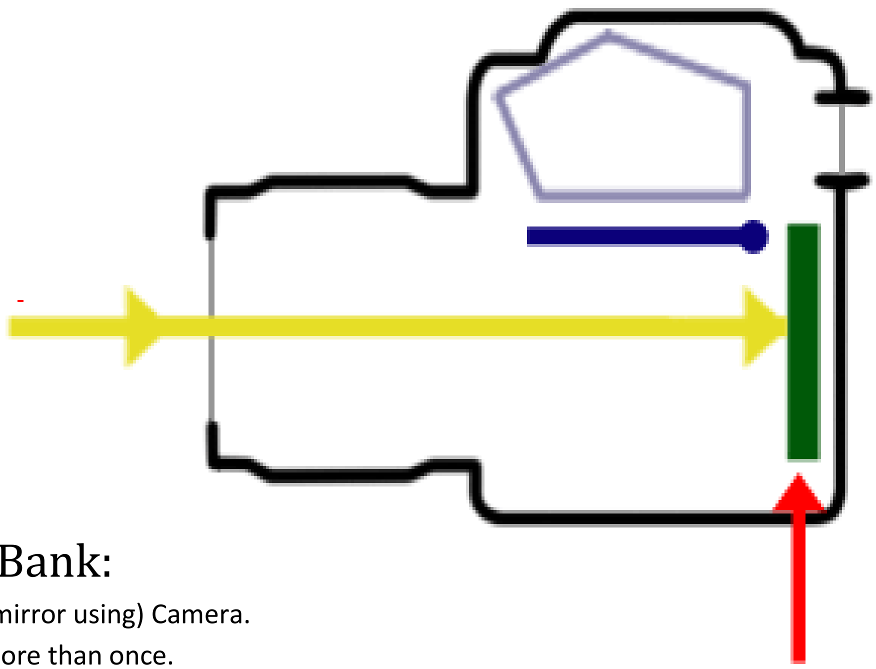


What is an obvious advantage of the camera with a mirror? List student ideas on the board. One obvious advantage of this system is accuracy. If the image you see through the viewfinder is not exactly the same as the image on the recording medium (as in viewfinder cameras), the resulting photograph may be noticeably different to what you expected. The SLR camera and its mirror system makes sure this doesn't happen. **What might be a disadvantage?** Ex: Weight of additional components. More parts something has, the faster it sometimes breaks down or the harder it might be to fix.

What Happens in a Camera with a Mirror?



Before the Shot



During the Shot

Word Bank:

Label each part of the SLR (mirror using) Camera.
Some words may be used more than once.

- Mirror
- Light
- Viewfinder
- Pentagram or mirror
- Lens
- Recording medium (film or digital)

Up Periscope!

Periscope comes from two Greek words, **peri**, meaning "around," and **scopus**, "to look." A periscope lets you look around walls, corners, or other obstacles. Sub-marines have periscopes so the sailors inside can see what's on the surface of the water, even if the ship itself is below the waves. All thanks to mirrors and reflected light!

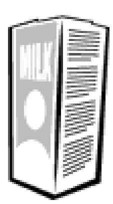
Materials:

- Two 1-quart milk cartons
- Two small pocket mirrors (flat, square ones work best)
- Utility knife (box cutter) or X-Acto knife, or sharp scissors
- Ruler
- Pencil or pen
- Masking tape

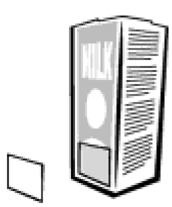
Note: X-Acto knives and box cutters are very, very sharp. If using one, adults should do the cutting in this activity.

Student Instructions:

1. Use the knife or scissors to cut around the top of each milk carton, removing the peaked "roof."

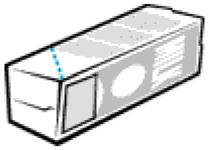


2. Cut a hole at the bottom of the front of one milk carton. Leave about 1/4 inch of carton on each side of the hole.

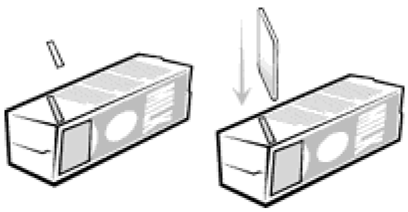


3. Put the carton on its side and turn it so the hole you just cut is facing to your right. On the side that's facing up, have students measure 2 3/4 inches up the left edge of the carton, and use the

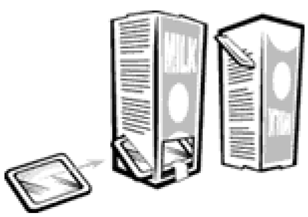
pencil to make a mark there. Now, use your ruler to draw a diagonal line from the bottom right corner to the mark you made.



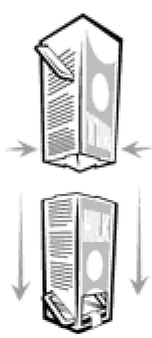
4. Starting at the bottom right corner, cut on that line. Don't cut all the way to the left edge of the carton-just make the cut as long as one side of your mirror. If your mirror is thick, widen the cut to fit.
5. Slide the mirror through the slot so the reflecting side faces the hole in the front of the carton. Tape the mirror loosely in place.



6. Hold the carton up to your eye and look through the hole that you cut. You should see your ceiling through the top of the carton. If what you see looks tilted, adjust the mirror and tape it again.
7. Repeat steps 2 through 6 with the second milk carton.
8. Stand one carton up on a table, with the hole facing you. Place the other carton upside-down, with the mirror on the top and the hole facing away from you.



9. Use your hand to pinch the open end of the upside-down carton just enough for it to slide into the other carton. Tape the two cartons together.



10. Now you have a periscope! If you look through the bottom hole, you can see over fences that are taller than you. If you look through the top hole, you can see under tables. If you hold it sideways, you can see around corners.

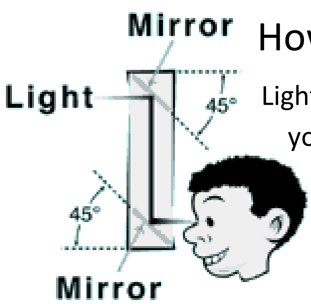
What kinds of mirrors can we use to make a periscope?

You need two small mirrors, but they don't have to be identical. If you have a rectangular mirror, or one with a handle, it's okay if part of it sticks out the side of the carton. If your mirror is round, like the mirror in a make-up compact, you may want to tape or glue it to a square of cardboard before inserting it into the slot in the milk carton. If you have a mirror with a magnifying side and a non-magnifying side, have the non-magnifying side facing the hole.

To make a periscope from a 1-quart milk carton, your mirrors must be smaller than 31/2 inches in at least one dimension. If the only mirrors you can find are larger than that, you can use half-gallon milk cartons instead.

What if we want to use half-gallon milk cartons or some other boxes?

When you are making a periscope, it's important to make sure that your mirror is positioned at a 45-degree angle. If you use a wider milk carton or some other box, just measure how wide your box is. Then measure that same distance up the side of the box and make a mark. The line between your mark and the opposite corner of the box will be at 45 degrees.



How does our periscope work?

Light always reflects away from a mirror at the same angle that it hits the mirror. In your periscope, like an upside down camera, light hits the top mirror at a 45-degree angle and reflects away at the same angle, which bounces it down to the bottom mirror. That reflected light hits the second mirror at a 45-degree angle and reflects away at the same angle, right into your eye.

Can we make a periscope with a really long tube?

They can make their periscope longer, but the longer the tube is, the smaller the image they'll see. **Why might this be?** Periscopes in tanks and submarines have magnifying lenses between the mirrors to make the reflected image bigger.

Flash from the Past!

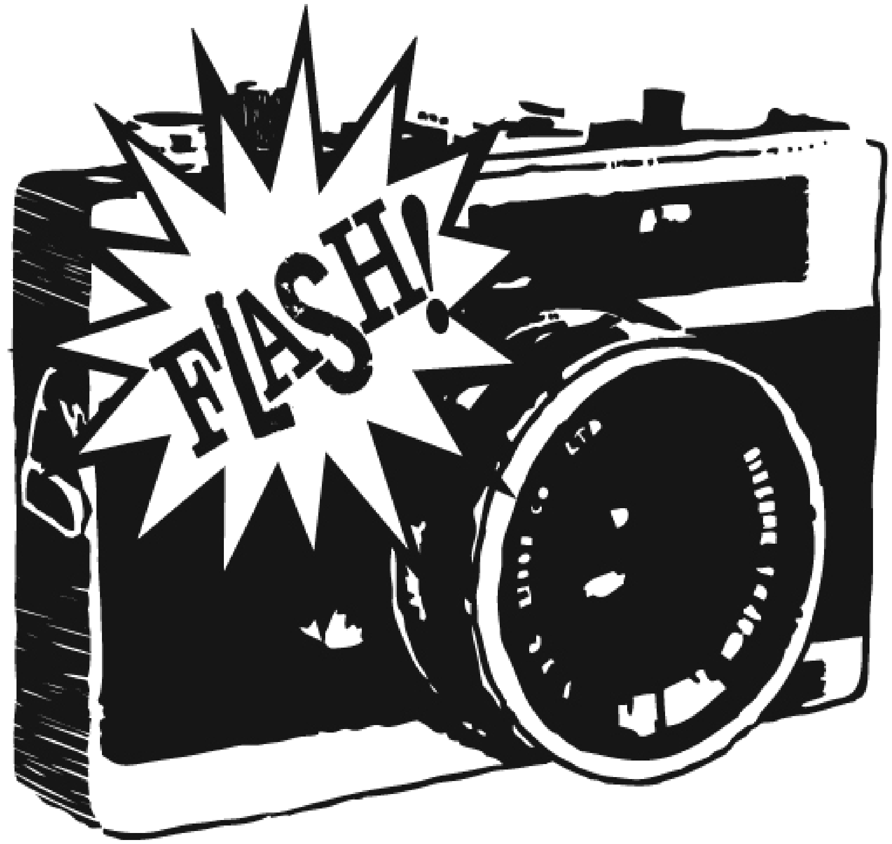


Image Credit: http://stephaniecorfee.com/collaborations/take-my-picture/. All Rights Reserved.

Cameras have been a part of our past, are definitely here today [camera phones, digital cameras anyone?], and continue to change our futures. It's only appropriate that we practice our tenses in honor of these cool inventions with the following fun activities.

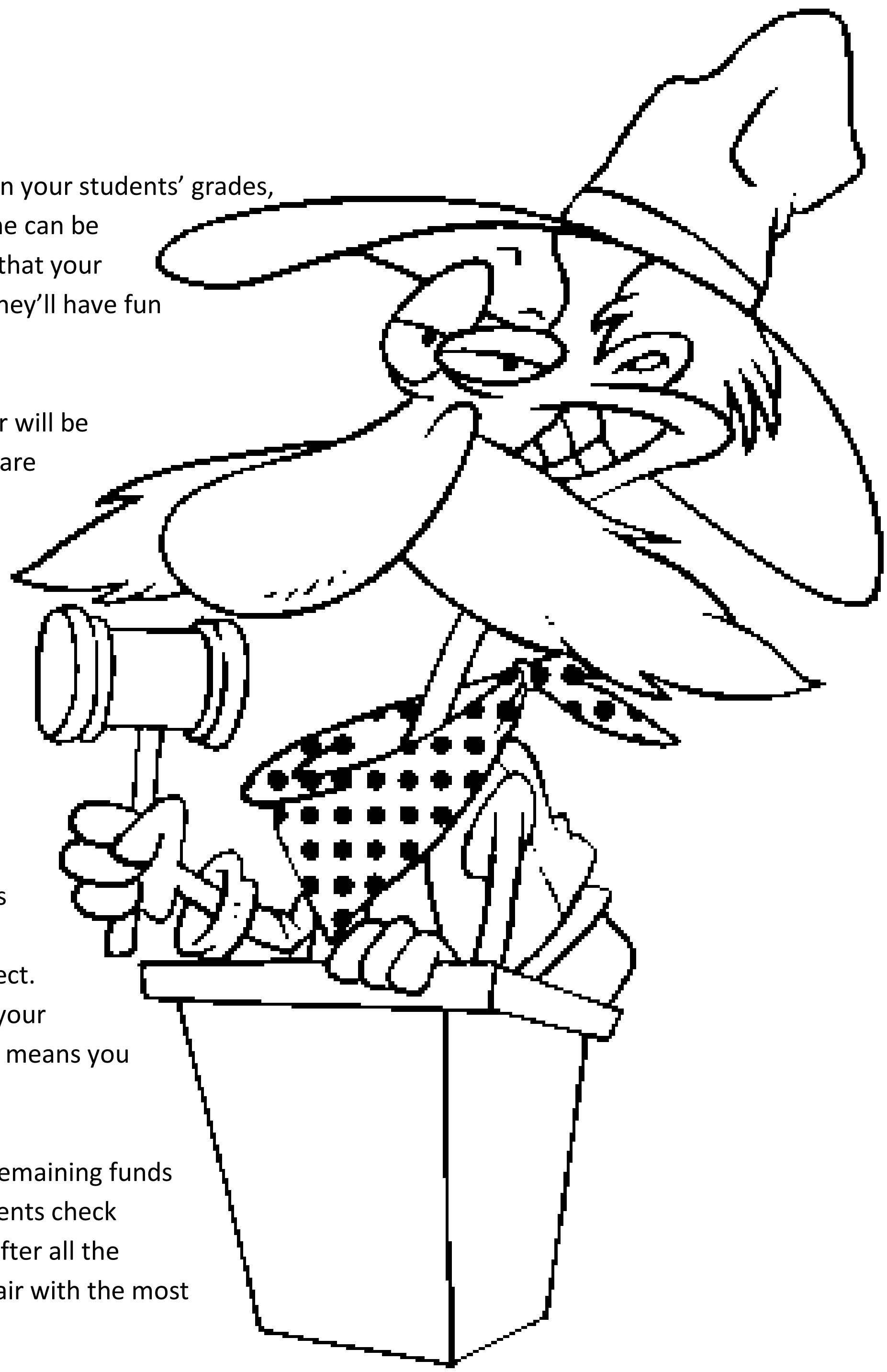
Delete the Verb

You can use this game to have students practice any tense they are learning. It's good for younger students and older. If you are practicing past tenses, write the past and present tenses of five verbs on the board in random places. Have two students, from different teams, come to the board and give each an eraser. Say a sentence such as "Yesterday I went to school; today I blank to school." The students have to race to erase the present tense of "went;" "go." Mix up the tenses of the sentences and write new verbs when there are only a few left.

Jeopardy

Using the format of the famous TV show "Jeopardy" is a good way to practice many tenses. Across the top of the white board write five titles, such as Places, Foods, Movies, Sports and Homework. Under each title, write point values from 100 to 500. If the student chooses 100, he must say a sentence relating to the title, using the present tense. If he chooses 200, he must use the past, and so on. You can choose the appropriate tenses. For example, if the student chooses Sports for 200, he could say, "Yesterday I played baseball." The difficulty of the sentence depends on the student's level. The winning team chooses the category.

Verb Auction



Develop a list of sentences based on your students' grades, standards, and skill levels. This game can be used to practice any grammar skill that your students need to hone up on and they'll have fun doing it.

Divide the class into pairs. Each pair will be given a list of auction items, which are sentences that use the needed grammar skill [ex. past tense, present tense, or future tense] and an imaginary amount of money, represented on paper or by play money. The auction list should include a 50/50 ratio of correct and incorrect sentences.

After the students review the auction list, begin the auction. Pairs will bid on each sentence based on whether or not they think it is correct. A correct sentence means you get your money back; an incorrect sentence means you lose your money.

Students must keep track of their remaining funds [subtracting as they go]. Have students check answers and count up the money after all the sentences are auctioned off. The pair with the most money at the finish wins the game.


FEDERAL RESERVE NOTE
THE UNITED STATES OF AMERICA
F 86420916 S
WASHINGTON, D.C.
ONE DOLLAR

FEDERAL RESERVE NOTE
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F 86420916 S
WASHINGTON, D.C.
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Sketchy Artists

While artists in subsequent centuries commonly used variations on the camera obscura to create images they could trace, the results from these devices depended on the artist's drawing skills, and so scientists continued to search for a method to reproduce images completely mechanically. It was not until the early 19th century, however, that photography actually came into being.
In the 19th century Henry William Fox Talbot, trained as a scientist at the University of Cambridge, could not draw his scientific observations, even with the aid of a camera lucida, and he dreamt of capturing the images of the world he could see on the screen. Talbot's own drawing abilities produced poor sketches. He began inserting chemically treated paper or metal plates at the back of the boxy camera obscura.

After numerous experiments he created a permanent light sensitive paper to capture the image and the art of photography was born. In 1841, he perfected this paper-negative process and called it a calotype, Greek for beautiful picture.

The word photography, derived from the Greek photos ("light") and graphein ("to draw"), was first used in the 1830s.– drawings from light. The modern camera, with all its bells and whistles, is really not that different from this first wondrous little invention that captures light, movement, and magic.

The first photograph was taken in 1827 by a man named Joseph Niepce. However, Niepce's photograph required eight hours, yes hours!, of light exposure to create and after appearing would soon fade away. Fellow Frenchman, Louis Daguerre was also experimenting to find a way to capture an image, but it would take him another dozen years before Daguerre was able to reduce exposure time to less than 30 minutes and keep the image from disappearing afterwards. Throughout the remainder of the 1800's, scientists would make gradual improvements on the camera and different methods of exposures.

A Not Very Popular Picture

Sometimes people just don't like getting their picture taken! Photography's remarkable ability to record a seemingly inexhaustible amount of detail was marveled at again and again. Still, from its beginnings, photography was compared—often unfavorably—with painting and drawing, largely because no other standards of picture making existed. Many people were disappointed by the inability of the first processes to record colors and by the harshness of the tonal scale. The photographic process at the time was sensitive only to blue light. Warm colors (red, orange, yellow, pink, brown) appear dark, cool colors (blue, purple, green, grey) uniformly pale. A sky with clouds is impossible to see, as the spectrum of white clouds contains about as much blue as the sky. Lemons and tomatoes appear a shiny black, and a blue and white tablecloth appears plain white. Victorian sitters who in photographs look as if they are in mourning (dressed all in black) might have been wearing bright yellow or pink. Critics also pointed out that moving objects were not recorded or were made blurry and indistinct because of the great length of time required for an exposure.

Despite these deficiencies, many saw the technique of photography as a shortcut to art. No longer was it necessary to spend years in art school drawing from sculpture and from life, mastering the laws of linear perspective and chiaroscuro (an effect of contrasted light and shadow in art). Others saw these realizations as threatening. For example, upon first seeing the first photo taking process demonstrated, the academic painter Paul Delaroche declared, "From today, painting is dead"; although he would later realize that the invention could actually aid artists, Delaroche's initial reaction was indicative of that of many of his contemporaries (people who lived at the same time). Such artists at first feared what Daguerre boasted in a 1838 broadsheet: "With this technique, without any knowledge of chemistry or physics, one will be able to make in a few minutes the most detailed views."

Covered in Film

Pictures were originally made on stiff "plates" made from glass or metal that were coated in light sensitive chemicals. This form of photographic material largely faded from the consumer market in the early years of the 20th century, as more convenient and less fragile films were introduced. However, photographic plates were still in use by some photography businesses until the 1970s, and were in wide use by the professional astronomical community as late as the 1990s. Such plates respond to 2% of light received. Glass plates were far superior to film for research-quality imaging because they were extremely stable and less likely to bend or distort, especially in large-format frames for wide-field imaging. Several institutions are setting up archives to preserve the original plates, preventing valuable historical astronomical data from being lost.

The wet process had a major disadvantage. The entire process, from coating to developing, had to be done before the plate dried. This gave the photographer no more than 10 minutes to complete everything. This made it inconvenient for field use, as it required a portable darkroom. The plate dripped silver nitrate solution, causing stains and troublesome build-ups in the camera and plate holders.

FYI

The wet plate collodion process has undergone a revival as a historical technique over the past few decades. There are several practicing photographers who regularly set up and do images at Civil War re-enactments. Many fine art photographers also use the process and its handcrafted individuality for gallery showings and personal work. There are several makers of reproduction equipment for the contemporary practitioner. The process is taught in workshops around the world and several workbooks and manuals are currently in print.

Despite its disadvantage, wet plate became enormously popular. It was used for portraiture, landscape work, architectural photography and art photography.

It is, in fact, still used by a number of artists and experimenters today.

The extreme inconvenience of shooting wet plates in the field led to many attempts to develop a dry process, which could be shot and developed some time after coating. A large number of methods were tried, though none were ever found to be truly practical and consistent in operation.

In 1878 George Eastman, an American innovator (a person who introduces new methods, devices, etc.) and entrepreneur (a person who starts and assumes the risk for a business), was one of the first to demonstrate the great convenience of gelatin dry plates over the cumbersome and messy wet plate photography prevalent in his day. Dry plates could be exposed and developed at the photographer's convenience.

George Eastman later invented roll film (tinkering at home to develop it), helping to bring photography to the mainstream. In 1888 he perfected the Kodak camera, the first camera designed specifically for roll film. In 1892, he established the Eastman Kodak Company, in Rochester, New York. It was one of the first firms to mass-produce standardized photography equipment. The company also manufactured the flexible transparent film, devised by Eastman in 1889, which proved vital to the subsequent development of the motion picture industry.

The first flexible roll films, dating to 1889, were made of material similar to guncotton (explosive soaked cotton fibers used as a propellant or explosive material) which would deteriorate over time. It is also highly flammable. Special storage for this film was/is required or it would burst into flames (it even burns under water!). It also decomposed after several decades into a no less flammable gas, leaving the film sticky and goo-like (and ultimately dust). Projection booth fires were not uncommon in the early decades of cinema if a film managed to be exposed to too much heat while passing through the projector's film gate, and several incidents of this type resulted in audience deaths by flames, smoke, or the resulting stampede; in one instance, at the Laurier Palace Cinema in Montreal on January 9, 1927, a fire broke out during a children's film program and resulted in the deaths of 77 children between the ages of 4 and 18.This kind of film is so flammable that intentionally igniting the film for test purposes is recommended in quantities no greater than one small frame without extensive safety precautions.

Despite the dangers of the nitrate film base being known practically since its development, nitrate film is historically important because it allowed for the development of roll films and it was used in virtually all major motion pictures prior to 1952. The first flexible movie films measured 35-mm wide and came in long rolls on a spool. In the mid-1920s, using this technology, 35-mm roll film was developed for the camera. By the late 1920s, medium-format roll film was created. It measured six centimeters wide and had a

Did You Know?

Many nitrate films have been transferred in recent decades to safety stock film, and original nitrate prints are generally stored separately to prevent a nitrate fire from destroying other non-nitrate films; the gas they give off also affects the emulsion of other films. Usually nitrate collections are even split up into several different fireproof rooms to minimize damage to an entire collection should a fire occur in one part. It is normal for a theater today to pass rigorous safety standards and precautions before being certified to run nitrate films; this includes a fireproof projection booth, fire chambers surrounding the feed and take-up reels, and several fire extinguishers built into the projector and aimed at the projector's film gate in case a trigger piece of film fabric ignites. Nitrate film is classified as "dangerous goods", which requires licenses for storage and transportation.

paper backing making it easy to handle in daylight. Nitrate film was produced in sheets (4 x 5-inches) ending the need for fragile glass plates.

More stable, flexible, and fireproof were developed later. Most films produced up to the 1970s were based on this technology. Since the 1960s, polyester polymers have been used for gelatin base films. The plastic film base is far more stable than previous films and is not a fire hazard.

Today, technology has produced films that offer greater detail and higher resolution, meaning sharper images.

- Film Speed (ISO) — An arbitrary number placed on film that tells how much light is needed to expose the film to the correct density. Generally, the lower the ISO number, the finer grained and slower a film. ISO means International Standards Organization. This term replaces the old ASA speed indicator. The slower the film, the more light is needed to expose it.

Printmaker, Printmaker, Make Me a Print!

1. While we don't want to expose young students to all the chemicals involved in wet process and film development techniques there are some fun ways to show them how materials can be light sensitive,

how images can be captured, and give a little insight into the process of making prints and film.

Materials

- Sun Sensitive Paper
- Water
- Containers to hold water in and papers, ex. 9x13 aluminum cake pans
- Cardboard and push pins to keep your prints in place or a shallow tub where the paper will be protected from blowing away in the wind
- Objects to take a "picture" of on the photosensitive paper

1. Have students collect objects that will make interesting prints (living (some students have put tiny frogs on the sheets), non-living, from nature, man-made, etc.)
2. Have students place their Sun Sensitive Paper, blue side up, in the shallow tub or pin the corners to a piece of cardboard for stability.
3. Place the objects they wish to "print" on top of the paper. If their objects are particularly lightweight, you can hold them in place with a piece of clear plastic wrap.
4. Expose the paper to the sun for 2-4 minutes, until the Sun Sensitive Paper turns very pale blue.

5. Students should remove the paper from the tray or cardboard and soak it in water for about one minute. Have students observe the change that occurs when the paper is placed in water.
6. Then, remove the paper from the water and let it dry flat. The image will sharpen as it dries.

Now Try This!

Another interesting way for students to see the chemical reaction that occurs with Sun Sensitive Paper is to test the effect of different types of light sources on the paper. They can test different light sources and the effect that various exposure times play in the process.
Some light sources to try if available:

- 100, 60, 40, 25 and 15 watt light bulbs
- Green, red, blue, yellow and black light
- Fluorescent light
- Bug light
- Infrared heat lamp

Have students try exposing the paper to each light source for set intervals of time, with zero exposure being their control in the experiment. Have students record their data and compare results between the light sources and exposure times.

How does it do that?

Basics: Like film, or photographic plates, the Sun Sensitive Paper is coated with light-sensitive chemicals, which react to light waves and particles when exposed to light. When you place objects on the paper, they block the light and turn white while the paper around them remains blue. Water stops the process and fixes your images on the paper. The intensity of the blue depends on the amount of time the paper is exposed to the light source and the intensity of the light source. For example, Sun Sensitive Paper doesn't work nearly as well on a cloudy day as it does on a sunny day.

More Details: In the lab, the sun paper/photosensitive paper is made by coating a sheet of paper with a water-soluble (Water-soluble means can be dissolved in water), bluish-green compound (compound means to mix things together, so it's a mixture) called iron (III) hexacyanferrate (III), Fe[Fe(CN)6]. The common name for this chemical is Berlin Green, a well-known photosensitive chemical. When exposed to ultraviolet light (UV), a chemical reaction takes place where the water-soluble Berlin Green changes into a water-insoluble (can't be dissolved in water) chemical called iron (III) hexacyanoferrate(II), Fe[Fe4(CN)6]3 The common name for this chemical is Prussian Blue. When you rinse your print in water, the water-soluble Berlin Green washes away, but the water-insoluble Prussian Blue remains fixed (stuck) on the paper. The intensity of the Prussian Blue depends on the amount of time the paper is exposed to the light source and the intensity of the light source.

Discuss the nature of sunlight and how light-sensitive chemicals work. From here, launch a discussion about how color photos are developed, as each layer of chemicals on the film reacts to photons (light particles) of different color.

Photographic Prints

Traditionally, linen rag papers were used as the base for making photographic prints. Prints on this fiber-base paper coated with a gelatin emulsion are quite stable when properly processed. Their stability is enhanced if the print is toned with either sepia (brown tone) or selenium (light, silvery tone).

Paper will dry out and crack under poor archival conditions. Loss of the image can also be due to high humidity, but the real enemy of paper is chemical residue left by photographic fixer. In addition, contaminants in the water used for processing and washing can cause damage. If a print is not fully washed to remove all traces of fixer, the result will be discoloration and image loss.

The next innovation in photographic papers was resin-coating, or water-resistant paper. The idea is to use normal linen fiber-base paper and coat it with a plastic (polyethylene) material, making the paper water-resistant. The emulsion is placed on a plastic covered base paper. The problem with resin-coated papers is that the image rides on the plastic coating, not the actual base. and is susceptible to fading.

At first color prints were not stable because organic dyes were used to make the color image. The image would literally disappear from the film or paper base as the dyes deteriorate.

Kodachrome, dating to the first third of the 20th century, was the first color film to produce prints that could last half a century. Now, new techniques are creating permanent color prints lasting 200 years or more. New printing methods using computer-generated digital images and highly stable pigments, offer permanency for color photographs.

[Nearly] Hassle Free Hassleblad

This carefully produced downloadable and printable net file represents an iconic Hassleblad camera as a low impact and functional product that is available to all.

Images created by the community of users will be viewable at www.pinholehassleblad.tumblr.com. Please send any images of your camera or produced by your camera to pinhole@kellyangood.co.uk to be uploaded to the blog.

Instructions

Please refer to the diagrams and very detailed step by step instructional video from Kelly Angood if you need further assistance or a visual reference to making your pinhole Hasselblad. http://vimeo.com/21702610 If you get stuck, just take a look at the time lapse video of the construction process, it shows the assembling of the camera in 18 minutes

Notes: Print this PDF on regular office paper at 1:1 (called 100% on some printers). DO NOT select 'fit to page'. To ensure that you have printed the document correctly measure the rulers on each page against a real ruler. If the document is printed smaller than intended your film will not fit in the mechanism!

Your pinhole Hasselblad will accept any 35 mm film. Use a 200ISO film for best results as this is what the suggested exposure times are based on.

FYI: Pinhole Cameras

A Pinhole image has to be a Slow Shutter Speed image. By revealing the pinhole light starts to pour into the camera - 4 seconds, 12 seconds, 30 seconds etc. We see much quicker than this – Our eyes seem to see things as they happen. However, in a slow shutter speed or pinhole image people blur if they move, or appear more than once – as the light reflected is distorted and marks the light sensitive paper.

Numbers on the tabs indicate which cut-out the tab should be glued to.

Apart from the print out you will need:

- A scalpel or craft knife
- A ruler (preferably metal)
- 2 regular paper clips A cereal box
- Either a 2cm x 2cm square of aluminum foil or a square of aluminum from a drinks can and a sewing needle.
- 3 sheets of black paper
- Spray adhesive or a glue stick
  Glue (UHU or PVA is recommended)
- 2 x 35mm 200ISO films
- A roll of black electrical tape
- A bottle opener

STAGE 1: Initial steps

8 00:00:00 > 00:00:38

1) Print out the PDF as instructed.
2) Cut away a roughly A4 sized section from your cereal box.
3) Using your glue stick or spray adhesive stick page one of the PDF to the printed side of your piece cereal box and stick pages 2-4 to your black paper.
4) Make all the cut outs from pages 1-4 taking special care to remove the inner cut outs from pieces 1, 10, 15 & 17.
5) Lightly score along the dashed lines on your cutouts to make folding easier.

STAGE 2: Making the main body

8 00:00:38 > 00:04:25

1) Fold cut out 1 into a three sided box and glue the tabs to the inside of the box to secure.
2) Now attach cut out 2 to the top of the box to complete the main body.
3) Take the rectangular cut outs
4). Glue the longer lengths to sides of the box, sticking them so that half of the width is inside the box and half sticking out. Do the same with the shorter lengths along the top and bottom of the box.
4) Now take cut out 3. Create a slight curve in the rectangular section be gently pulling the paper through your fingers. Do this to the upper and lower parts of the rectangle.

5) Now glue the tabs to the inside of the rectangular section. You may wish to hold some of the tabs together with paper clips whilst the glue dries.
6) When both the front box section and rear curved section are dry take your black electrical tape and tape along the inside of the joints. This is to prevent light-leaks.

STAGE 3: Making the roof

8 00:04:25 > 00:07:17
1) For this section you will need cut outs 5,6,12, a paper clip and a sewing needle.
2) Construct cut out 6 by folding along the dashed lines, making a slight curve at the front where the tabs are and gluing the tabs to the inside of the side sections.
You may wish to hold the tabs to the main roof body with paper clips whilst they are drying.
3) When dry take your sewing needle and punch a hole through the small marker on both cut-outs 5 and 6.
4) Now glue cut out 5 to the top of the main body where indicated.
5) Open out your paper clip and shape as illustrated in the diagram.
6) When 5 and 6 are dry feed the paperclip through the holes you have made in 5 and 6 to attach them together. This can be a little tricky. When the mechanism is in place you should be able to move the roof of the Hasselblad up and down.
7) Now fold cutout 12 into a three sized box and glue the
striped area to the inside of the inside of the roof section (6).
8) When dry hold the back of 12 with your fingers and push down 6 with gentle force. This will allow you to move the roof up and down and create the folds as illustrated in the diagram.

STAGE 4: Making the lens & side sections

8 00:07:17 > 00:10:40
1) For this section you will need cut outs 7, 8, 9, 10 & 11.
2) Take cut out 7 and fold down the triangular tabs on both sides.
3) Glue the triangular tabs marked 7 to the inside of the black circle and glue the two ends together where they meet.
4) Now glue the triangular tabs marked 1 to the circle on the side of the main body.
5) Now take cut out 8 and glue it to the circular surface of cut out 7. (See diagram)
6) Take section 9 and fold down the triangular tabs and glue to the front of the main body as previously done on cut out 7 taking care not to cover the cut out circle on the main body.

7) Glue cut out 10 to the inside of section 9.
8) Take cut out 11 and do not fold the tabs down but instead glue the tabs to the inside of section 9.

STAGE 5: Making the film mechanism

8 00:10:40 > 00:16:56
1) For this section you will need cut outs 15, 16, 17, 18, & 19. You will also need a 2cm x 2cm square of tin foil or aluminum, a sewing needle, black electrical tape, two 35mm films and a bottle opener.
2) Take cut out 15 and glue the tabs marked '15' to the inside of the box.
3) Now take section 17 and fold along the score line and
glue together so that the black side is facing outwards.
4) When dry, place cut out 16 into cutout 17 and glue section 19 across the thinner section of the inner cut
out from section 17 to prevent the slider from falling out. (See diagram).
5) Now take your square of tin foil or aluminum and place a pinhole directly in the centre then glue around the outer edges and glue to section 15 so that the pinhole is roughly in the middle of the central square cut out.
6) Glue the constructed sections 16, 17 & 19 to the front of section 15 as shown in the diagram.
7) Whilst that section is drying gently ease off the bottom of a 35mm film using a bottle opener. Take care not to damage it too much as the removed section has to be used again.
8) When you have removed the bottom, take out the film from the canister and discard.
9) Now remove the spool from the canister and turn it upside down.
10) Now pull a few centimeters of film from the second 35mm film canister and feed it into the empty spool.
Depending on the film you are using you may need to cut some of the film away to create a tab to feed into the empty spool. You may also need to use a little electrical tape to make sure that the film is attached to the empty spool securely.
11) Slide the spool back into its canister and push the section you removed with the bottle opener back onto the canister to secure.
12) You are now ready to attach the film to the constructed mechanism.
13) Place the exposed film onto the back of section 15 and fold the section with the rectangular cut out on top of the film.
14) When in place push the tabs into the film feed of the canisters. This helps to prevent light leaks.

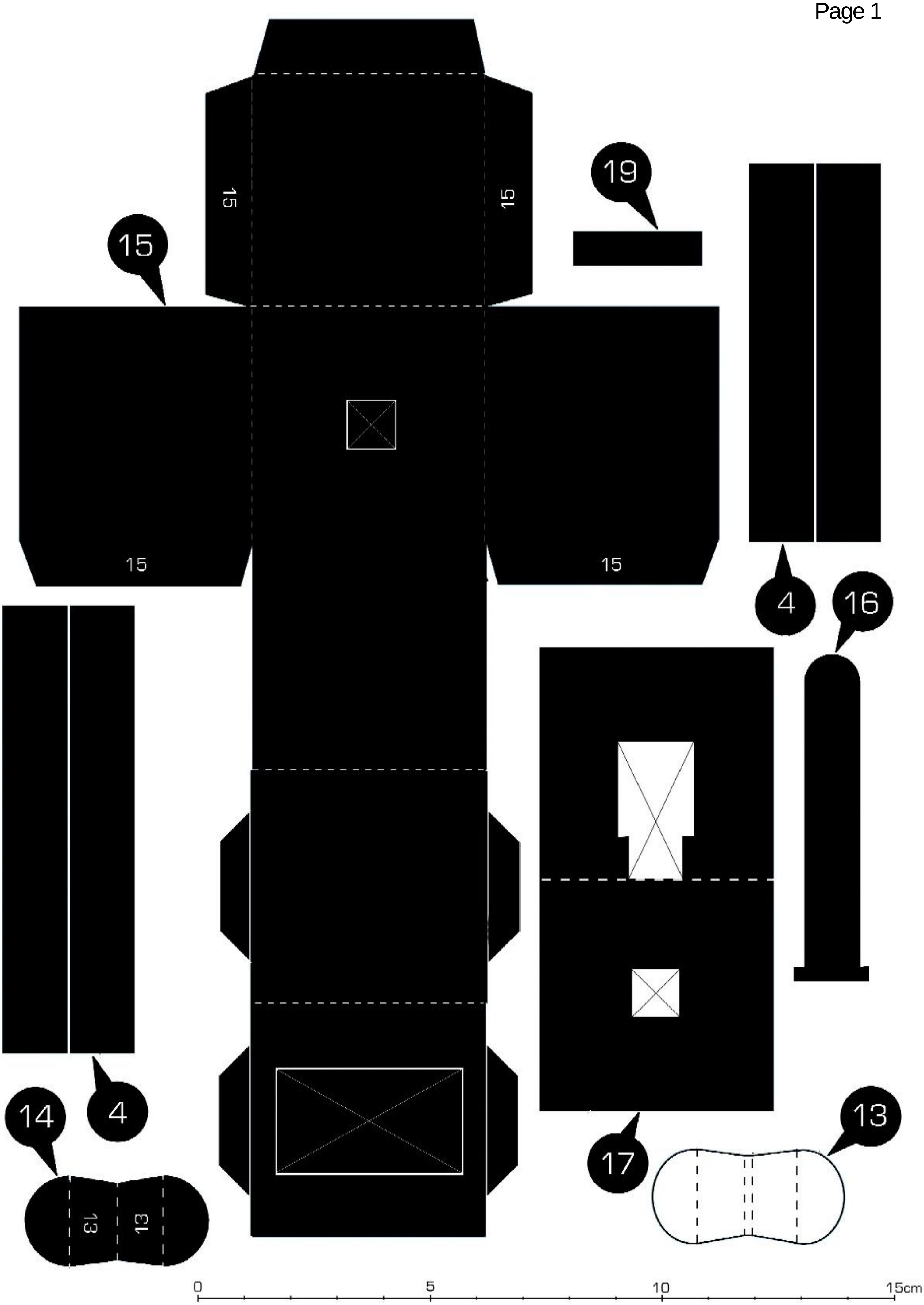
15) When you have done this fold the last remaining tab over the back of the box and secure with black electrical tape to complete the section.
16) If you feel that there is anywhere in the mechanism where light could leak in (apart from the pin hole) cover with black electrical tape.
17) When the mechanism is fully dried, place glue to the front of the mechanism taking care to avoid the slider.
18) Then feed the mechanism into the main body of the camera, feeding the slider through the small
rectangular cut out on the right of the main body.
19) When in place open the slider to ensure that the pinhole can be seen through the cutout in the front of the main body and that the side of the bottom film is accessible through cut out at the side of the main body.
20) When fully in place, close the slider and allow to dry fully.

STAGE 6: Making the film advance mechanism
8 00:16:56 > 00:18.30
1) For this section you will need a paper clip and cut outs 13 & 14.
2) Bend the paper clip as shown in the diagram.
3) Glue cut out 14 to the folded cut out 13.
4) Glue the shaped paper clip into the constructed sections 13 & 14. You may wish to use a paperclip to hold these in place whilst it dries.
5) When dry, place the constructed winder into the bottom film canister. This mechanism winds the film on, in the first instance make about 8 full winds before you take your first photo and from then on wind the film 1.5 full turns between each exposure.

Your pinhole Hasselblad is now ready to use. To get a sharp photo, it's important to hold your pinhole camera steady Ex. Attach it to a tripod with rubber bands, or a brick, or whatever method your students determine.
When the film is finished, remove the tape holding the mechanism together, remove the film and pull the film away from the top spool and feed it into the bottom spool. You can now take your film to a commercial photo processor for developing. You may want to inform the developer that not all the photos may be clear, as sometimes developers do not . As the exposures on the negatives are not spaced standardly you will need to inform the developer, or you can use a negative scanner, if it's available, to upload them into your computer for editing.

Option: Send any images of or from your pinhole camera to pinhole@kellyangood.co.uk to be published on the blog www.pinholehassleblad.tumblr.com!

Option: Time Lapse Photography Have students use a regular digital camera to take a series of photographs of the project at different stages of development. The object of time lapse photography is to speed up a process that the normal human eye cannot see because the process moves so slowly. Then put the photos together, either on a poster board or as a slideshow, with captions, and show how the camera developed.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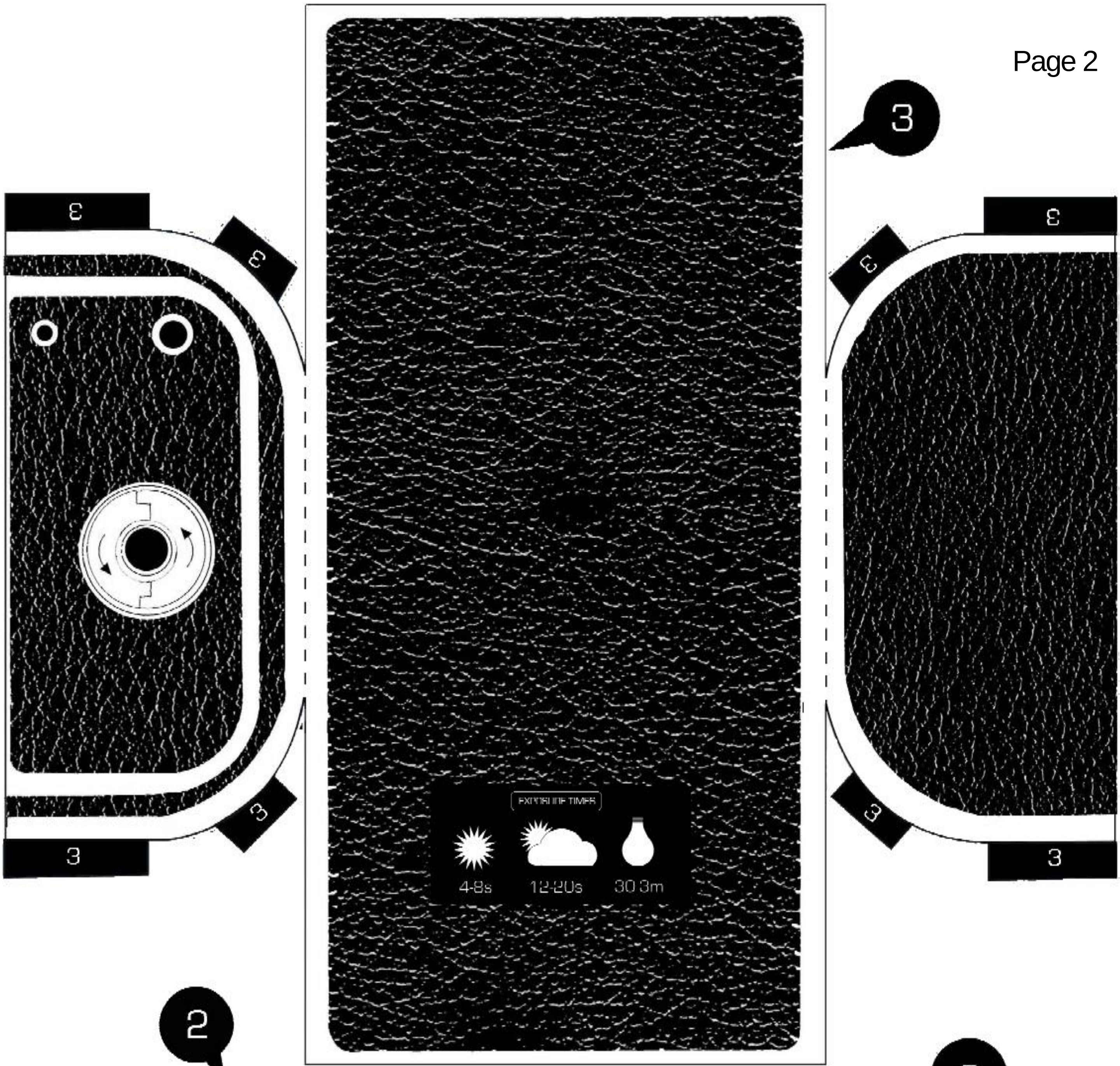
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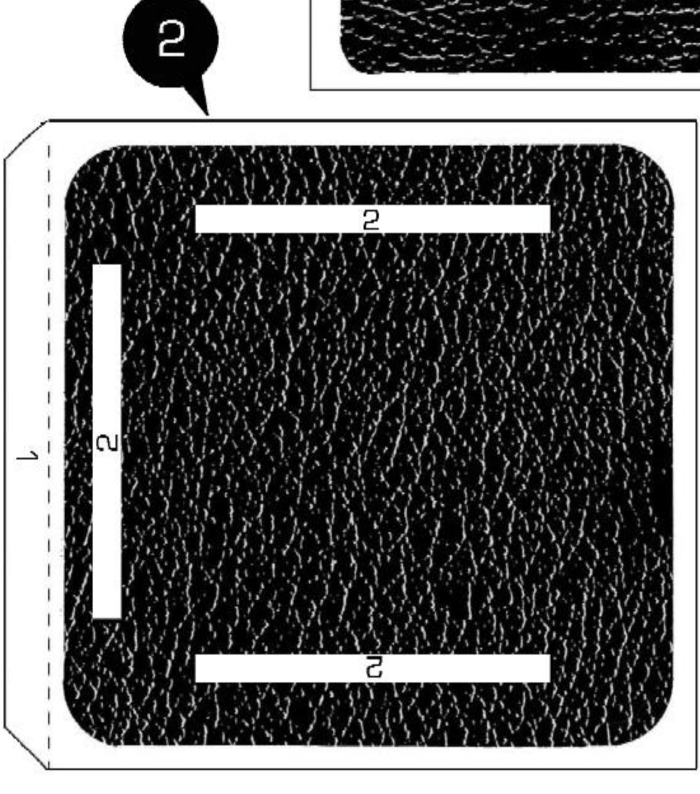
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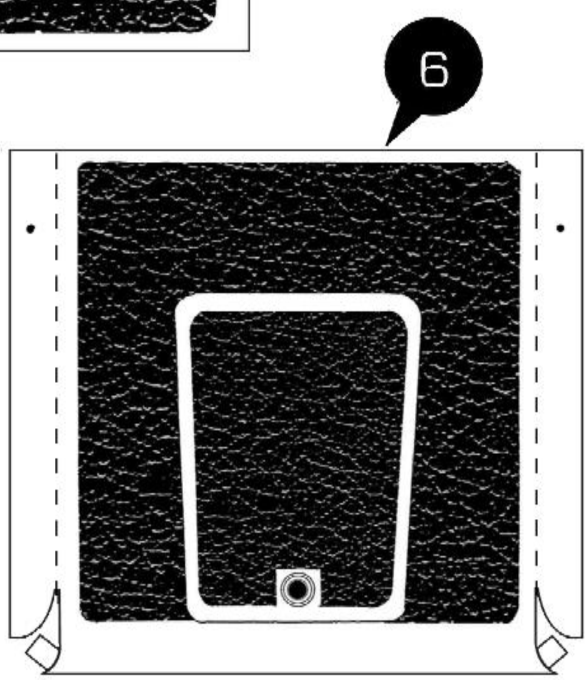
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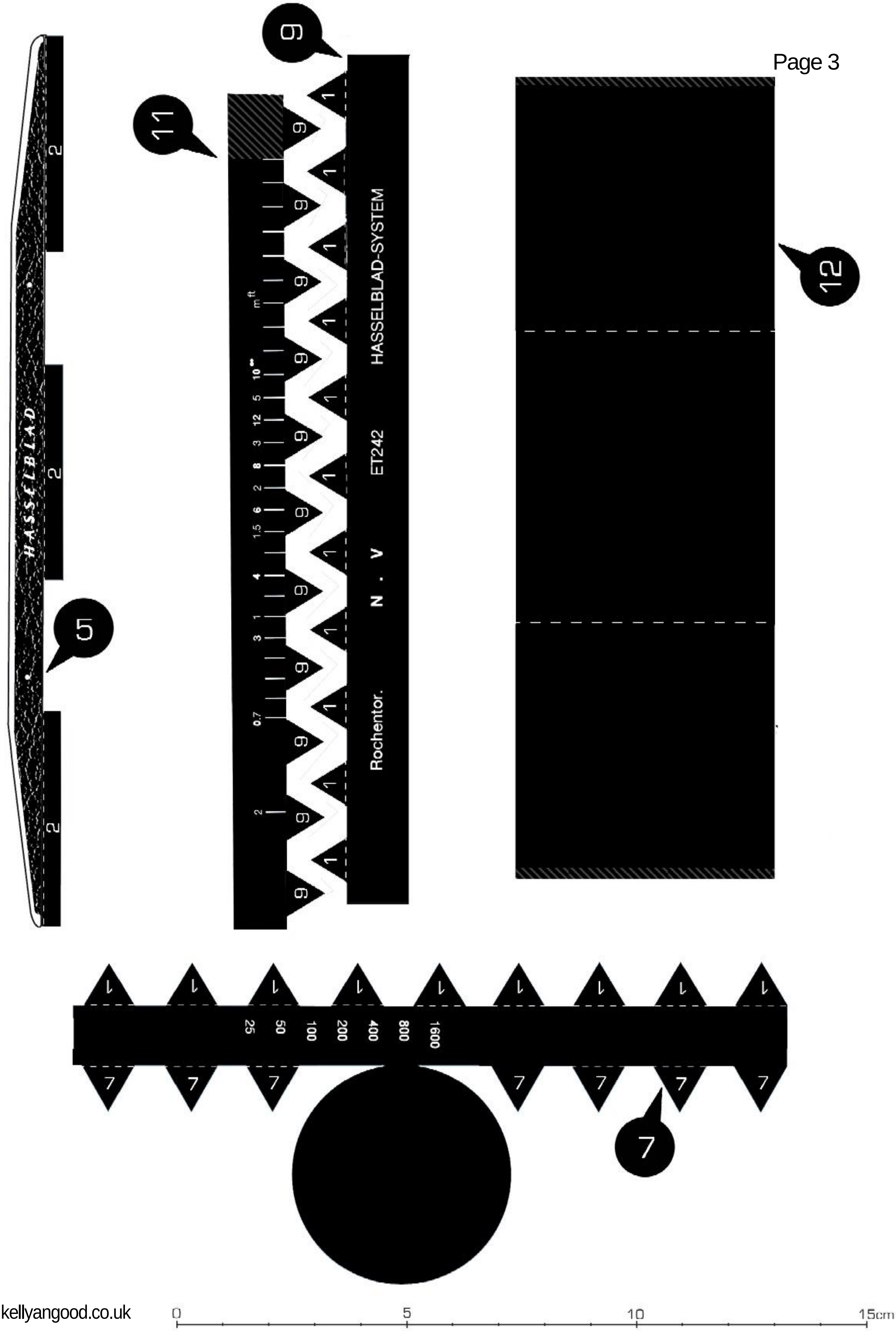

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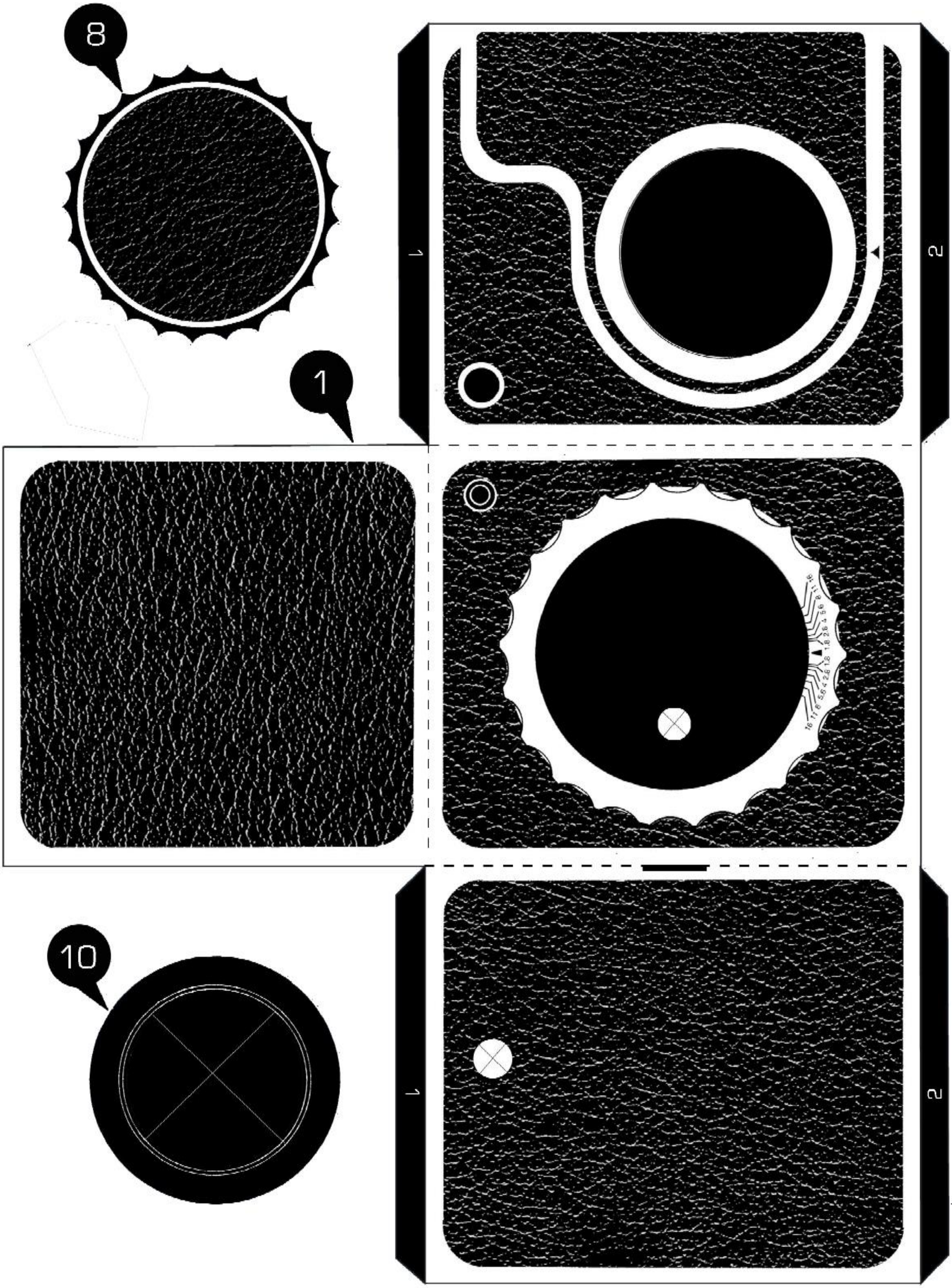

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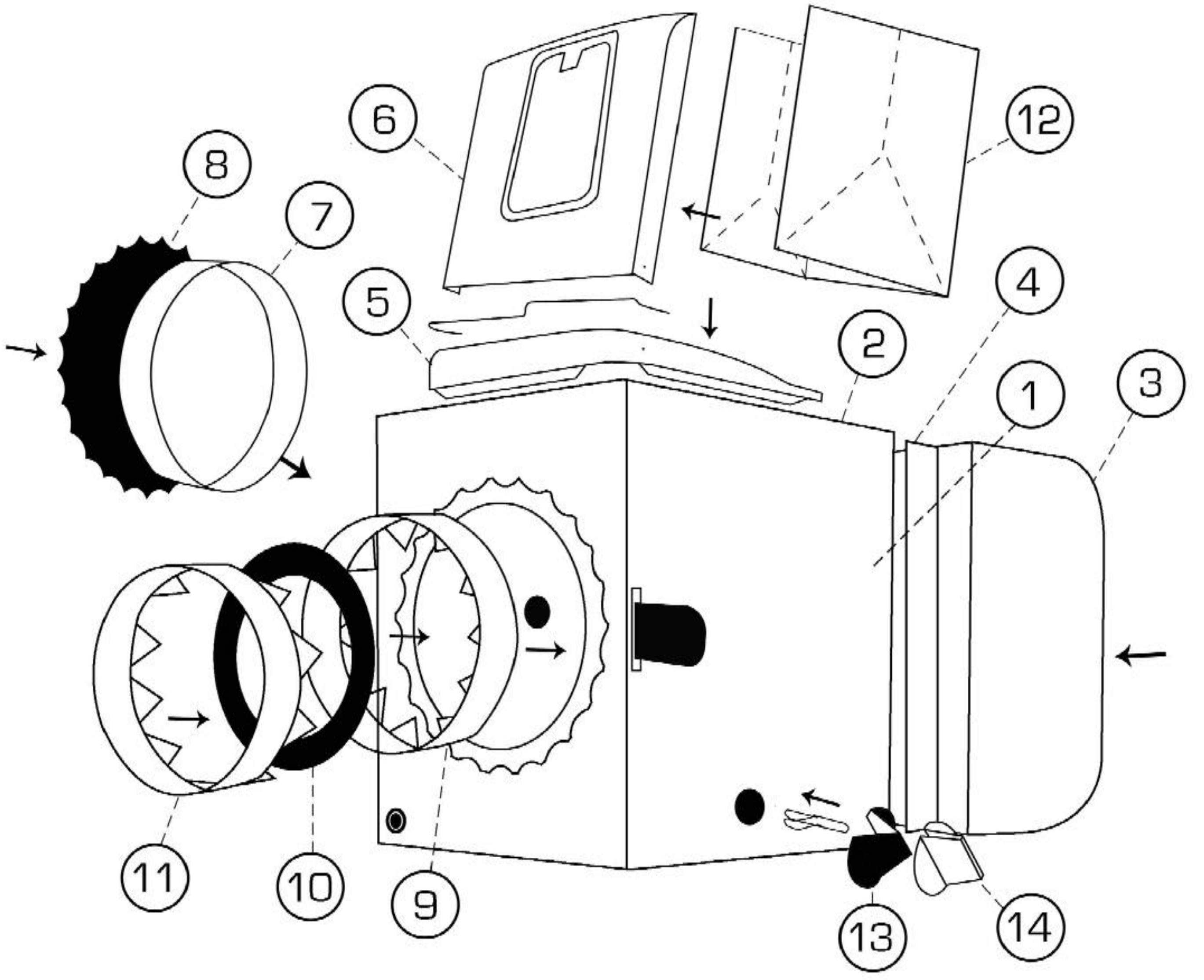
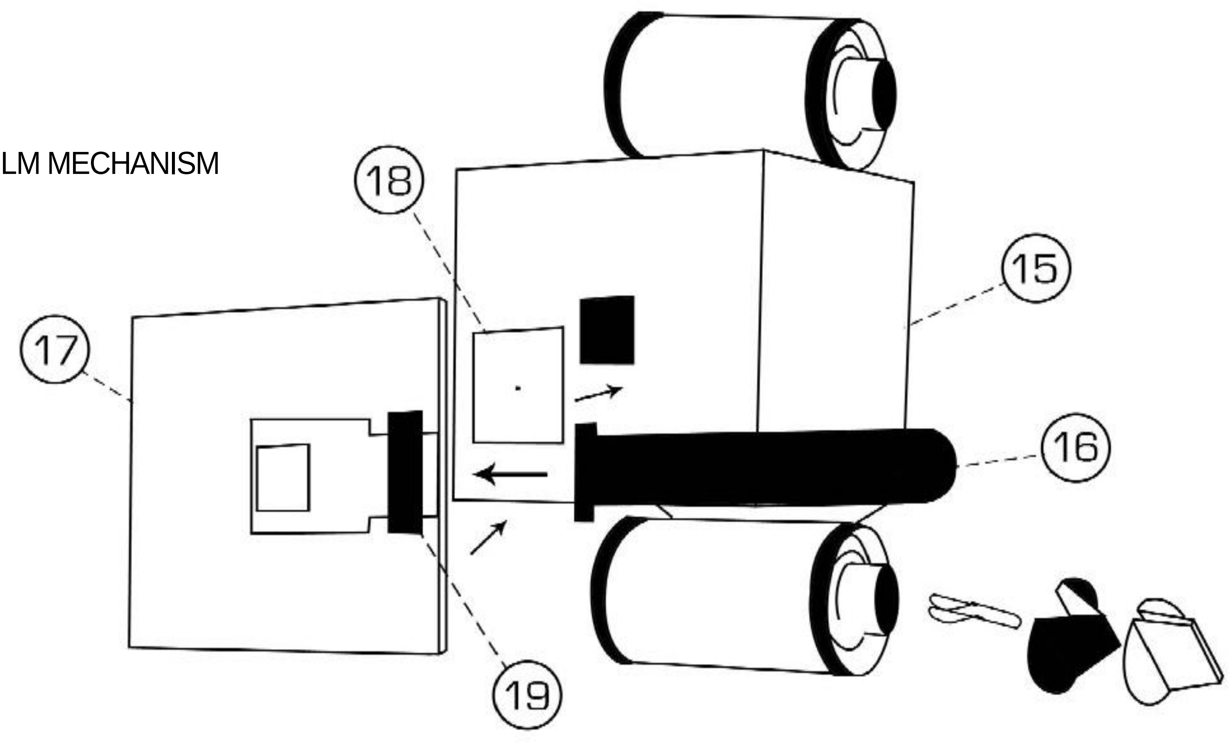
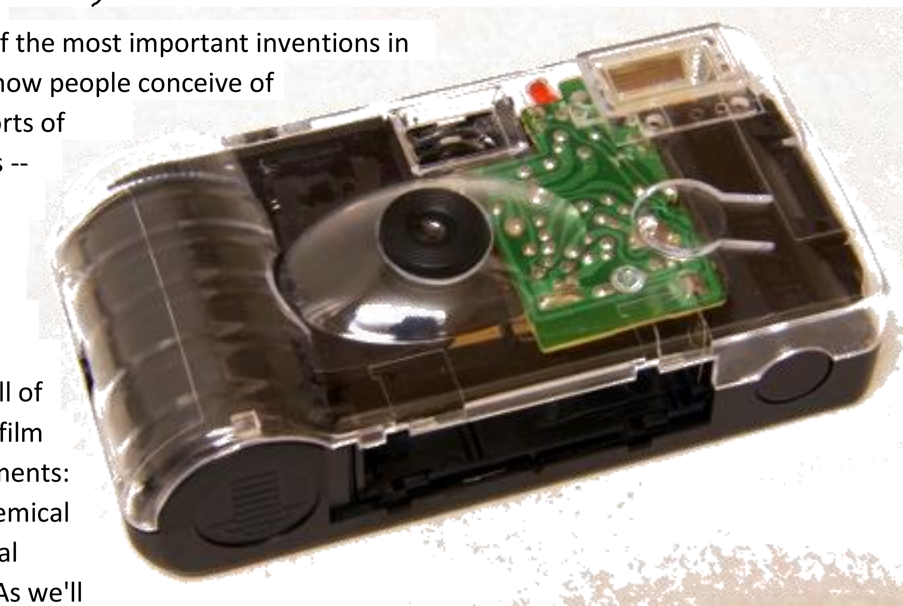
MAIN BODY



FILM MECHANISM



Our Day: Reverse Engineer a Modern Camera



Photography is undoubtedly one of the most important inventions in history -- it has truly transformed how people conceive of the world. Now we can "see" all sorts of things that are actually many miles -- and years -- away from us. Photography lets us capture moments in time and preserve them for years to come.

The basic technology that makes all of this possible is fairly simple. A still film camera is made of three basic elements: an optical element (the lens), a chemical element (the film) and a mechanical element (the camera body itself). As we'll find, the only trick to photography is calibrating and combining these elements in such a way that they record a crisp, recognizable image.

Have you ever wondered how something worked, and so you took it apart? Well that in nutshell is called reverse engineering. Reverse engineering has become a powerful tool in the engineering community. It is done on a daily basis within companies around the world.

Reverse engineering takes a finished product with the aim of discovering how it works by testing it and then being able to suggest improvements.

The engineering design process includes five critical steps:

1. Ask - What is the problem? What have others done?
2. Imagine - What is the best solution? Brainstorm ideas.
3. Plan - Draw a diagram. List the materials you need.
4. Create - Follow your plan and test it out.
5. Improve - How can you improve your design? Go back to Step 1.

To do these activities divide the class into two or more groups to disassemble one of two different brands of a single-use camera. Students create a systems diagram and precise reassembly instructions for the device. They then attempt to rebuild the other camera using instructions developed by their peers. Through this reverse engineering activity, students learn about the work of systems engineers.

Note: It is helpful to reverse engineer both kinds of cameras yourself to anticipate where students might need help and the kinds of questions they may ask.

This lesson also provides an opportunity to discuss ethical issues that engineers encounter, and in particular, the debates that surround the practice of reverse engineering.

Objectives

By the end of this activity, students will be able to:

- Analyze the component systems and subsystems of a device and classify them as mechanical or electrical.
- Classify the component parts of the device according to their materials and recyclability.
- Create a systems diagram to describe the operation and control of the device.
- Identify the purpose of subsystems as input, process, output, or feedback.
- Explain product lifecycle in terms of technological impacts.
- Follow instructions and diagrams created by others to reassemble a common product.
- Discuss the ethical concerns about reverse engineering.

Materials

- Bins, boxes, or containers to collect metal, plastic, and other parts for recycling at the end of the activity

For each team:

- Fuji and Kodak single-use cameras, one for each team
- Safety glasses
- Black electrical tape
- Small flat head screwdrivers
- Pliers
- Small storage containers, envelopes, or bags to hold smaller parts from the devices
- Gallon-size Ziploc bags to hold all the materials
- 8-1/2"x11" or larger white paper to create systems diagrams (note: larger paper may be easier for students to use and include more information)

Safety considerations

1. Require students to wear safety glasses throughout the activity.
2. To prevent small electrical shock, tell students that they should ***NOT*** press the flash button. Students working with a Fuji camera should remove the cardboard cover and the AA battery before pressing the shutter.
3. For both kinds of cameras, have students cover the lens with a small piece of black electrical tape and use the shutter and film advance wheel until "0" (zero) appears. This will aid in disassembly and make it possible to use the film later on.
4. Students working with a Kodak camera should remove the battery immediately after opening the camera.
5. Collect the batteries and film for future use.

Please allow this letter…

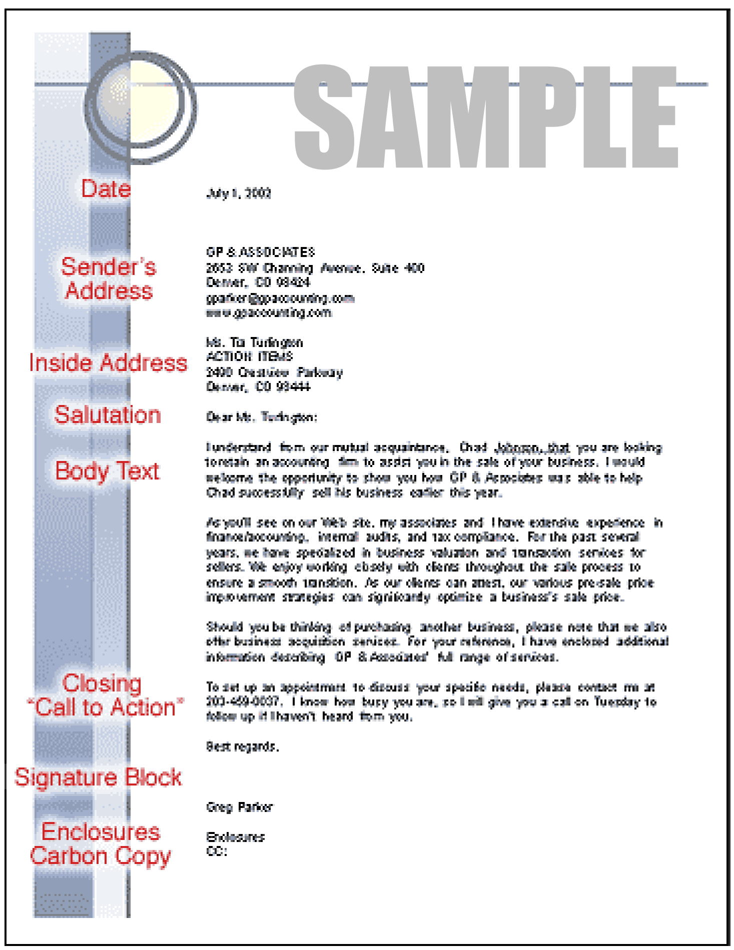
We live in an age of fast-paced, frequent communication. Texting, tweeting, e-mail and instant messaging often assault us from every side. Even so, the classic means of communicating, business letters, personal letters, etc. are still important for students to learn.

Students from several classes may take part in the project. Each class has to produce clear instructions for their partner class, and reassemble a camera using material from that same partner class.

Have students compose a formal class letter of introduction or business letter to exchange with your partner participating class. Discuss with students that your business letter is a representation of your company/team, so you want it to look distinctive and immediately communicate "high quality.” Ask students whether they should put smiley faces, or use casual, chatty language in a business letter or if it should be friendly but more professional.

Because business letters are more formal, encourage your students to type the final drafts of their letters. If you have the resources available in class, you can have students type during their writing workshops. If you have a computer lab at the school, your class can type their letters from the beginning. If neither of these are a possibility, have your students write their letters in their very best penmanship.

Have students begin with a return address and date, justified on the left side of the page. After the date, students should skip a line and then include the name of the person or group to whom they are writing, Mr. or Ms. and then first and last name. Below that, students should include the recipient’s address. All of these pieces will be in line on the left side of the page. Students should then write the greeting, again left justified. This time they will address their letter with Mr. or Ms. followed by the person’s last name and a colon. This colon is different from the comma used in a personal letter.



With a business letter, instead of indenting each paragraph, they will be left justified, but your students will skip lines between the paragraphs to separate each one. Again, give your students class time to write the message.

In the body of the letter students can include information such as:

- Name of your class teams and grade levels in your class.
- What do you think your class

could most contribute to this effort?

- What are your goals and expectations in participating in this collaborative effort?
- Any other information that you would like to share about your class and goals.

Encourage students to choose lively, active words to hold their reader's attention, keep it friendly and professional, and to be sure to sound like themselves - they don't want their letter to read as if a machine wrote it.

In the final paragraph they want to state what the reader needs to do and what your group will do to follow up.

And then finally, the closing or valediction. The closing will be left justified like the rest of the letter, but you will want to take some time with your class to brainstorm closings appropriate for a business letter. The most common closing will be sincerely, but your students can also use best regards or any other closings you think are appropriate. When typing the letter, tell students to skip three lines and then type their names, first and last. After the letter is printed, your students should sign their name by hand with blue or black ink.

Quick Tips: The specific parts of a business letter:

- Date: Use month, day, year format, e.g., March 3, 2012 or 3 March 2012
- Sender's Address: It is a good idea to include sender's email and website, if available. Don't include this information if it's already incorporated into the letterhead design. This will allow customers to find your small business more quickly.
- Inside Address: Use full name. Mr./Ms. is optional
- Salutation: Be sure to use a colon at the end of the name, not a comma as in personal letters
- Body Text: State why you are writing. Establish any connection/mutual relationship up front. Outline the solution, providing proof in the way of examples and expert opinions. Group related information into paragraphs
- Final Paragraph "Call to Action": State what the reader needs to do and what your group will do to follow up
- Closing/Signature Block: Sign your letter in blue or black ink
- Enclosures: Use if you have included something with your letter
- Carbon Copy: Use if you are sending a copy to additional person(s)

Now that your students are finished with the letter itself, it is time to address the envelope. Give them a larger, business envelope. The full sheet of paper on which they typed their letters should be folded into thirds and then will fit perfectly into the business envelope. Most business letters will have a printed envelope, but this may be beyond what you want to do with your class, especially with younger students. You can have your students address the envelope, affix the stamp and mail. Your students have now completed their business letter and can “mail it” and wait for a response from the other class.

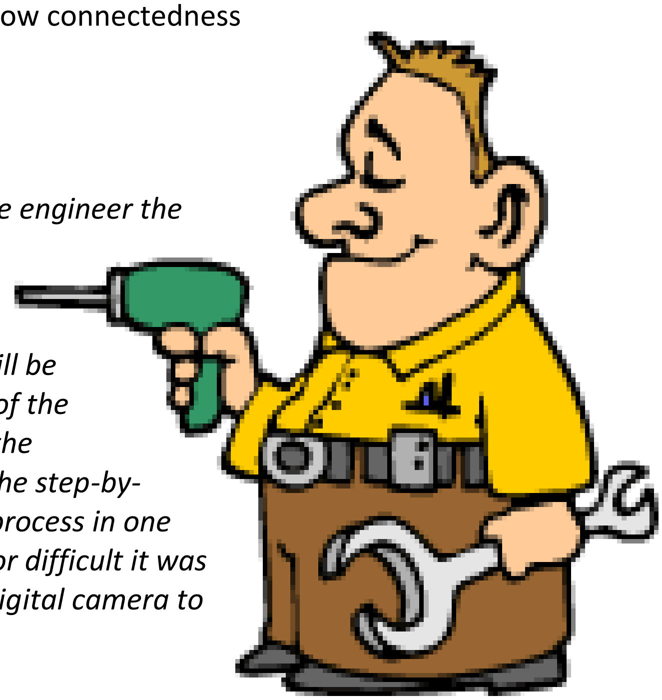
During the project, have each class had to produce clear instructions for their partner class, and reassemble a camera using material from that same partner class.

Split Decision

Divide the class in two, with each half assigned to work on either a Fuji single-use camera or a Kodak single-use camera. Split the class into smaller teams of 3-5 students, supplying each with a camera.
Have students follow the directions below.
Tell the students that they will be creating a systems diagram for the device that they have been assigned to take apart during class.
A system is collection of different elements that interact to produce results that are not obtainable by the elements alone. An automobile is made up of thousands of parts and each part must work with the others if the vehicle is to function as desired. From a functional viewpoint systems have inputs, processes and outputs. Inputs are the resources put into a system, ex. gas into a car. Processes combine the resources to produce the output which can be a product, service or enterprise. From a physical viewpoint, the system consists of mechanical, electrical and software components (and even humans) that interact to realize these functions. Many engineered systems, particularly those that incorporate electronics, are built in a way to determine if the system is working properly, ex. your check engine light might come on in your car if something isn't working right. To do this the goal of the system and the output are compared. This is called feedback. So if your car is supposed to have free flowing gas, but something is blocking it, then the input (amount of gas) is compared with the output (amount of engine power) and your check engine light comes on.

Explain to students how systems and interactions can be displayed using a systems diagram and provide an example. Point out how different shapes may be used to illustrate different types of subsystems and that arrows or lines may be used to show connectedness and/or interaction between subsystems.

Dis...assemble?



Work as a team to reverse engineer the device your teacher provided. The ideal team will be made up of 4 members. One person should do the physical disassembly. Most parts snap together, and no tools will be required for disassembly but be careful because many of the parts are delicate. A second team member should use the included Disassembly Procedure Table that describes the step-by-step process of disassembly. They should describe the process in one column and use another column to describe how easy or difficult it was to complete each step. The third member could use a digital camera to *record images of individual parts and subsystems. Later on, they can add these images to the table. The fourth member should carefully observe the disassembly process so that he/she will be able to lead the process of assembling the camera and help the group to identify the function of each part and give it a name based on its purpose and appearance.*

Note: A small screwdriver will facilitate disassembly. It should be used carefully to avoid damaging parts.

1. Explain how students should proceed with taking apart their device: Caution them to be aware of sharp parts, and to be careful not to break or lose any pieces. If necessary, assist them with removing or taking apart difficult pieces. Remind that that they should document each step of the disassembly process using notes, drawings and/or digital photography, and that they must identify the function of each part and give it a name based on its purpose and appearance.
2. . Have the students organize the component parts of their device on their work area according to their organization/function. Caution them to not lose track of small parts. Continue until all major components of the system have been dismantled. Students should only go as far as to dismantle the major subsystems. These include: power/battery, film advance mechanism, lens, and flash.
3. Have the students continue the deconstruction of their device all the way down until they can classify a component as metal or plastic. If more than one class period is needed to disassemble the device, place the devices in a container with all their parts and store them where they can be accessed in the next class session.
4. Once the students have completed taking apart their devices have a discussion and include the Disassembly Questions:

1. How do the parts work together to create systems within the device? Describe one of the systems.
2. Think about the engineering of this product. Identify some of the requirements, specifications and constraints that must have influenced the design, material selection and manufacturing of the product.
3. What kinds of tradeoffs do you think the engineers had to make?
4. Identify at least two issues for the product. What parts do you think will be the most difficult to dispose?
5. What kinds of materials were used? Why were these materials selected?
6. What kinds of specialists do you think were involved in the design of this product?

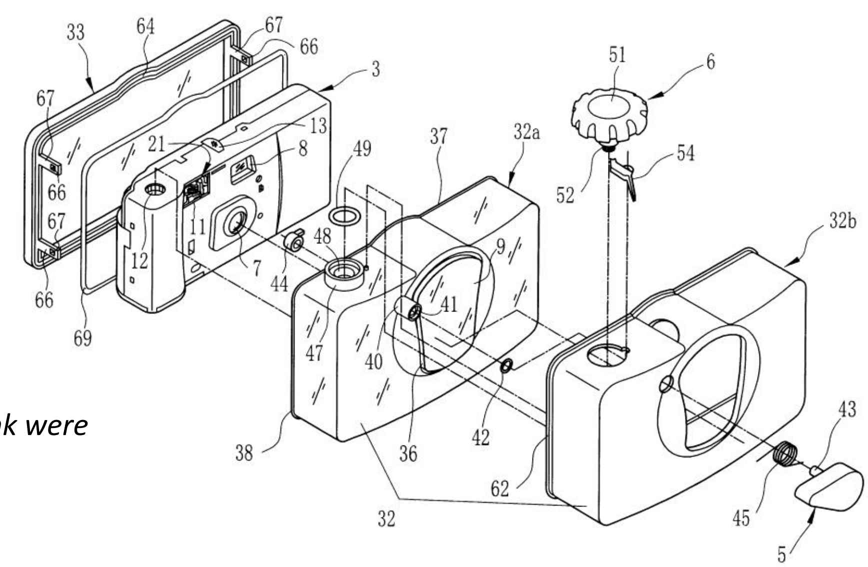
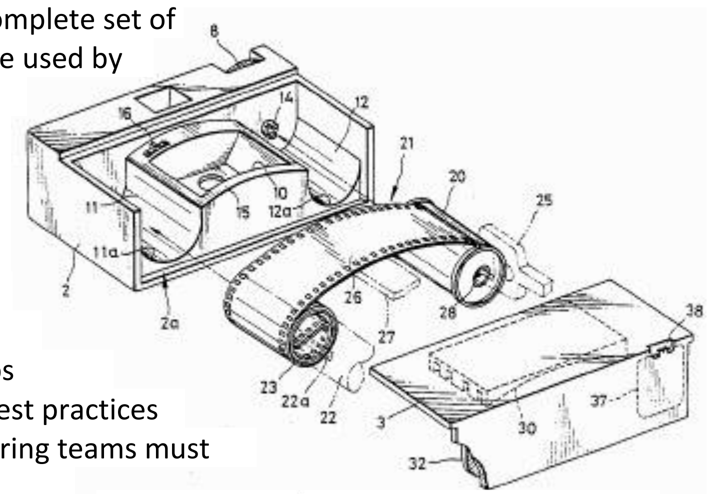


Diagram it!

Have the students sketch a systems diagram for their device (Or, if time is a limiting factor, have students take pictures with a digital camera of each step and phase of disassembly). Discuss the sketches briefly and then have them move on to create a more final version of the diagram. Initial sketches should be done by hand, and final versions may be done either by hand or using computer software (note: Microsoft Word and PowerPoint include drawing tools that may facilitate creating diagrams with specific shapes). Remind students that they may use different shapes or colors to enhance their diagram for purposes of explanation and illustration.

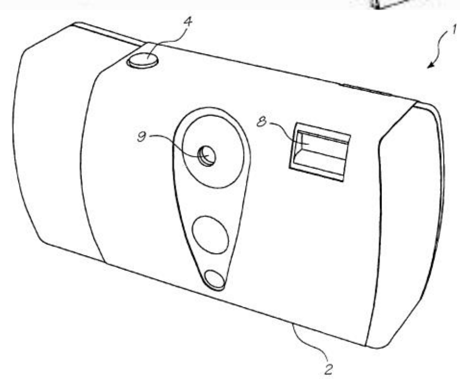
Follow My Steps!

Students should now work together to create a complete set of assembly instructions for their device which will be used by the other team. They may need to practice assembling it as part of that process but they should leave each device disassembled when they are finished. The instructions may include diagrams, images, photos, or any other information that would be essential for another team to reassemble this device completely and correctly. The creation of this final document helps encourage comparison, analysis, and critique of best practices — the kind of collaborative work systems engineering teams must undertake in their professional projects.



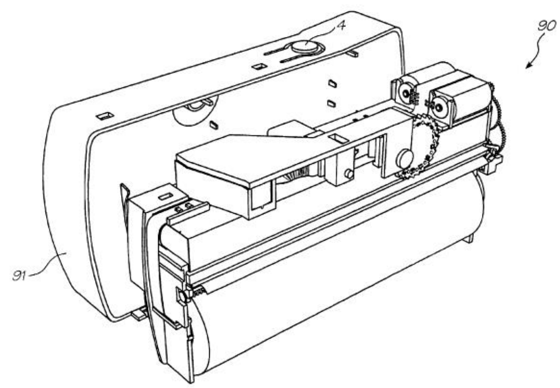
Directions to Students:

1. After the product has been completely disassembled and catalogued, work as a team to reassemble it as completely as possible.



2. Create a second table that includes the name of each part, function, digital image and re-assembly instructions.

3. Prepare a brief report that compares what you expected to find inside the camera before and what you found during disassembly.



4. Prepare a complete set of reassembly instructions that may include diagrams, images, or any other *information that would be essential for another team to reassemble this device.*

5. Collaborate with other teams in your class that are also creating reassembly instructions for the same device. Work together to select or refine one complete set of instructions that represents the best efforts of your class.

6. Once your teams have produced the final set of instructions, disassemble the devices again and give the components to your teacher who will give your disassembled device to a different team in your class.

Once each team has completed their assembly instructions, they will collaborate with other like teams in the class to select and/or refine one complete set of instructions for that particular device. If there were 3 teams each working on the Fuji camera, they should now convene as one large group to review each of the team's assembly instructions and work together to come up with a modified set of instructions based on all teams' input. Encourage students to discuss the helpful and positive aspects of the instructions, and even how they could be improved further, rather than focusing upon which team did "better" than another. This final set of best instructions will be the one shared with the other half of the class or the other partner class.

Carefully collect the component parts in the large Ziploc bags or other storage containers so that all the components for one device remain together. The bags will later be distributed to opposite teams for them to reassemble using the instructions from either the other half of the class or the partner class.

Just Put One Part in Front of the Other!

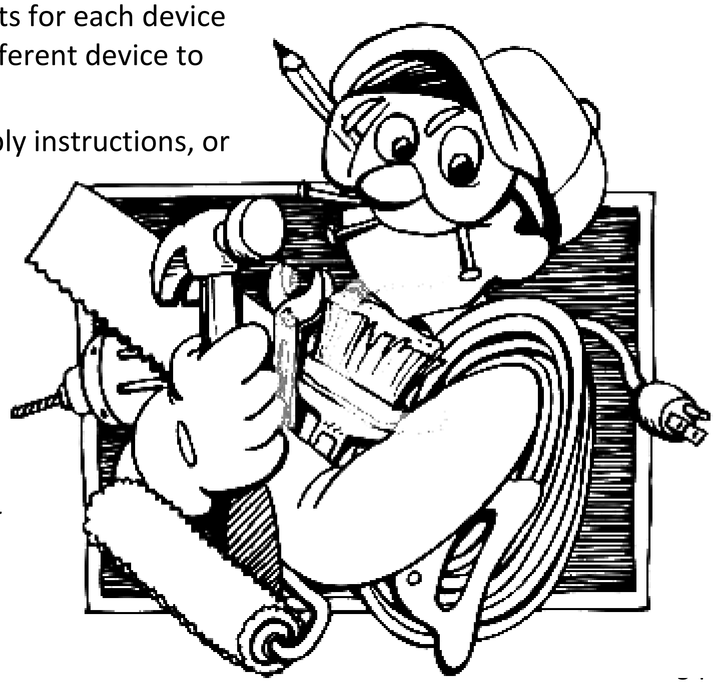
1. Distribute the disassembled components for each device to class teams so that each team has a different device to work with.

2. Have teams access the online reassembly instructions, or supply them with the hardcopy handout.

Directions to Students:

Obtain the disassembled components for the other camera — not the one you previously took apart. Review the reassembly instructions for this camera that have been provided by the other half of your class or your partner school.

Your team should reassemble this product given ONLY the instructions provided.



As a team, discuss the aspects of the directions that are unclear or incorrect. Your teacher will instruct you about providing this feedback to your partner teams.

The project concludes when:

- *You successfully assemble the new device based on another class' instructions and*
- *Your partner teams successfully assemble your device based on the instructions you provided.*

3. Each team should reassemble this product using ONLY the instructions provided, with no communication from their "other half" or hints from the teacher [this may be modified according to your students' grade levels].

4. Teams can discuss the aspects of the directions that are unclear or incorrect and either write out their comments, hold a meeting with the other teams also working on the same camera, or hold a meeting with the teams that produced the instructions.

5. If working with a partner class, be sure to communicate with those students once your teams have successfully re-assembled the device. If possible, teachers may wish to convene the entire group to discuss the results and students' assessment of what they have learned about the systems engineering process.

6. Collect the component parts in large bins. Explain to the students that you will see to it that the items are disposed of properly and according to local laws.

Ethics of Reverse Engineering:

Engage students in a consideration of the ethics [what is right and wrong] involved in reverse engineering a product; while our classes and other students, like engineering students who participate in a reverse engineering activity during their undergraduate [college/university] education which helps them learn about systems and systems engineering, may use the approach to understand the inner working of a device, others may use it to alter or copy a product. **Do students think that a good or a bad thing?** Typically reverse engineering is done by companies that seek to infiltrate [get into] a competitor's market or understand its new product. In doing so they can produce new products while allowing the original creator to pay all the development costs and take all the risks involved with creating a new product. Analysis of a product in this way is done without technical drawings or prior knowledge of how the device works **(why wouldn't they have that? They didn't make it!)**, and the basic method used in reverse engineering begins by identifying the system's components,

followed by an investigation into the relationship among these components.
Reverse engineering is a controversial subject. **Have students brainstorm why it might be controversial, list their ideas on the board.** While the companies performing it may be at a distinct advantage, saving both time and money, the original creator of the design may be severely affected by the increased competition. **How?** There are two basic legalities associated with reverse engineering:

a. Copyright Protection - protects only the look and shape of a product.

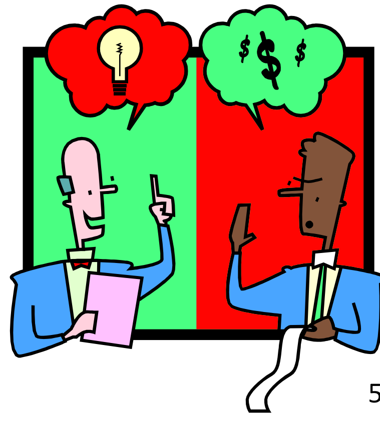
b. Patent Protection - protects the *idea* behind the functioning of a new product.

What do students see as the difference between the two? Which offers more protection? Does either? What might be their weaknesses? Although design patents can protect an engineer or company from this kind of activity, the security this can offer is limited. By reverse engineering a product, companies can discover original ideas that are not protected; in doing so, they can infringe another's intellectual property rights. It is therefore important that designs are not disclosed to competitors and protection is in place to prevent fraudulent activity.
There are also benefits to reverse engineering. Reverse engineering might be used as a way to allow products to work together. Also reverse engineering can be used as a check so that a product isn't performing harmful, unethical, or illegal activities.
What do students think? If an individual or an organization produces a product or idea, is it ok for others to "disassemble" the product in order to discover the inner workings and create their own competing product?
Although reverse engineering is legal as long as another person or group does not explicitly copy another product, the ethical debate is sure to endure. One argument for reverse engineering is summed up by an analogy offered by Jennifer Granick , director of the law and technology clinic at Stanford Law School, "You have a car, but you're not allowed to open the hood." Other companies, such as Lexmark will argue that reverse engineering infringes upon their intellectual property.
Should all uses of reverse engineering be discouraged? What are the pros? What are the cons?

Pro and con grid

Time requirements: 15-20 minutes
Help students develop analytical and evaluative skills, and encourage them to go beyond initial reactions to complex issues as they evaluate the pros and cons of reverse engineering.
Procedure

- Divide students into small groups, if necessary.
- Specify how many pros and cons you'd like each individual or group to develop.
- Allow five to ten minutes for discussion or silent thought.
- Ask for input: write pros on one side of the board and cons on the other side.



- Combine pros and cons that are very similar, and count the number of times they recur to show their perceived importance.

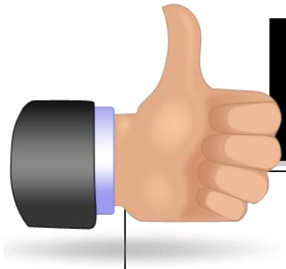
Debate it!

Consider using the pros and cons as the basis for a debate using the following method. There are no clear cut answers, but engaging students in a consideration of ethics can help students understand the larger implications of engineers' work. Remind them that reverse engineering is not limited to machines and products but can also involve the study of nature and bio mimicry (a new science that studies nature's models and then uses these designs and processes to solve human problems.).

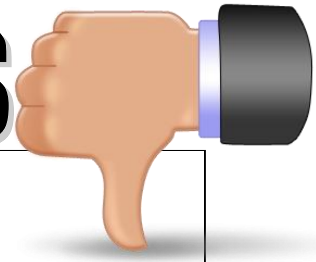
Debates can be formal or informal: what follows is a method for an informal debate (i.e., debating as a method of class discussion). A debate is a good way to encourage class participation in large groups without losing control.

Procedure

1. Describe the background context (covered earlier), and explain why you are having a debate.
2. Consider establishing ground rules for the discussion (ex. Disagreements are welcome, name calling and interruptions are not).
3. Decide on the two (or more) sides to the debate.
4. Physically group the class according to points of view: either assign students a point of view depending on where they sit, or ask people who want to argue each point of view to move to sit together.
5. Invite someone from one side to begin the debate by stating his/her point of view.
6. Invite someone from the other side to state the opposite point of view.
7. Open the floor to comments that question or expand on the issues that were raised.
8. For large groups, you may want to have speakers raise their hands while you moderate, but for small groups, anyone can speak up.
9. The debate will probably start slowly at first, but the intensity should pick up as the students become more comfortable with the new style of in-class interaction.
10. You, as moderator, can ask provocative questions, but don't express judgment on any point of view or students will hesitate to bring out new ideas for fear of being embarrassed.
11. After 10 to 15 minutes of debating, end the debate. What conclusion have they reached?



Pros	Cons

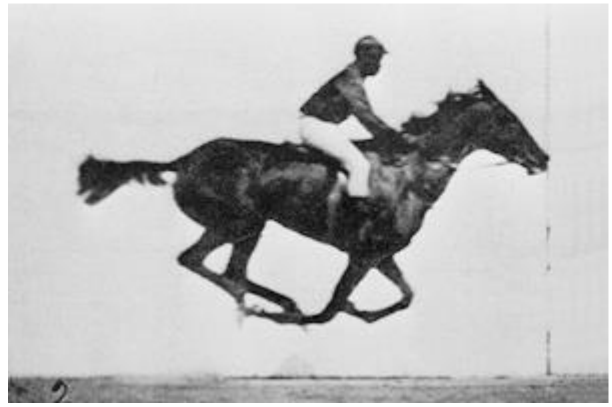


Disassembly Procedure

Item	Description of Process	Level of Difficulty

Horsing Around with Pictures

In the 1870s, a man named Leland Stanford had a large farm at which he bred, trained and raced both Standardbreds, used for trotting races in which a driver rides in a sulky (little cart with a seat and wheels) while driving the horse; and Thoroughbreds, ridden by jockeys and raced at a gallop. He was interested in improving the performance of his horses of both types and in the scientific questions of their gait action (how they moved when they ran). Stanford had a theory that at some point in its stride, a trotting horse has all four feet off the ground at the same time. He had tried various ways of measuring the horse's footfalls, but none were successful.



Legend has it that Stanford wanted to settle a $25,000 bet by proving that horses “flew,” but most historians doubt that colorful bit. Stanford had retired to the life a country horse breeder, and he wanted proof of what his eyes told him was true. The new medium of photography offered the possibility of that.

Mr. Muybridge the photographer, was intrigued, but history says he plainly told Mr. Stanford that such a thing had never been heard of; that photography had not yet arrived at the point where it would enable it to depict a trotting horse at speed. Mr. Stanford simply said: "I think if you will give your attention to the subject, you will be able to do it, and I want you to try." So the photographer had nothing to do but "try."

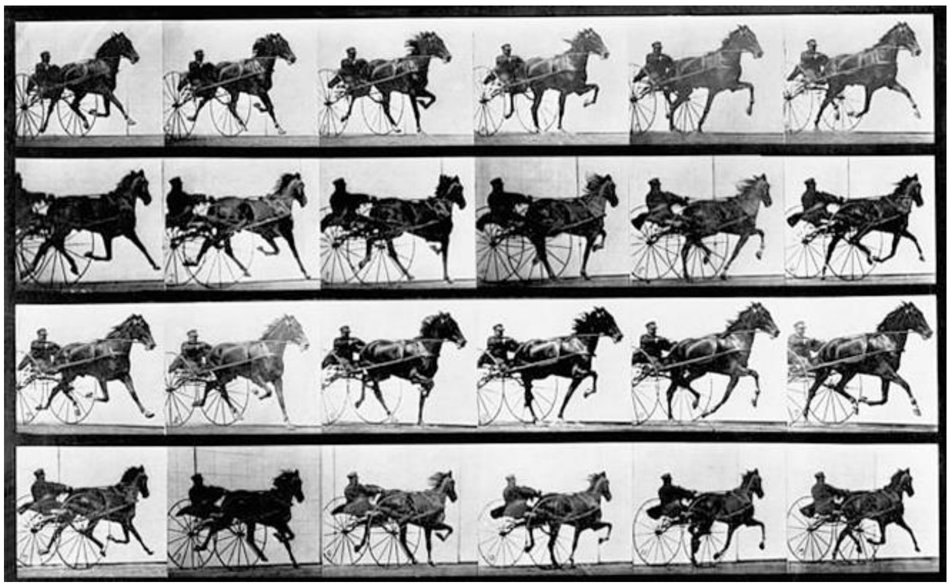
Stanford initially staked Muybridge $2,000 for the project, but over the next six years the project cost $50,000 — twice the apocryphal (of doubtful authenticity, although widely circulated as being true) wager and about $1.1 million in today’s money. Many photographers were still using exposures of 15 seconds to one minute, **what might a problem with that be?** Ex. a horse ran much much faster than that.

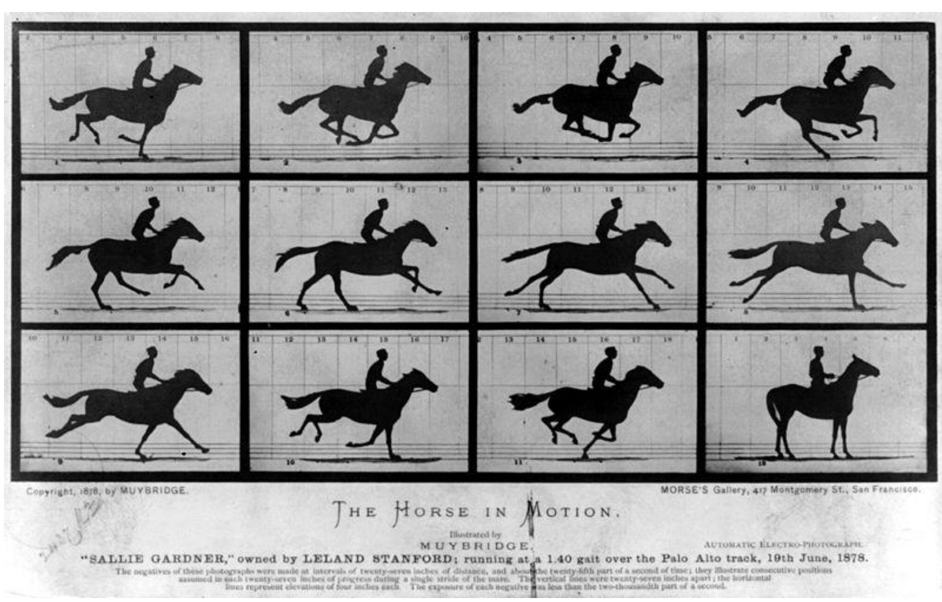
Automatic shutters were in their infancy: expensive and unreliable. For most film, all you had to do was remove the lens cap or even cover the lens with a hat or large black cloth. Muybridge devised more-sensitive film and worked on elaborate shutter devices. He also rigged a series of trip wires across a racetrack, letting the horse’s chest push against the wire to engage a shutter mechanism that would open the camera and make the exposure.

This system produced an “automatic electro-photograph” on July 1, 1877. It showed Occident, a

Stanford racehorse, seemingly with all four feet off the ground. The press and the public failed to accept this as proof, however, because what they saw was obviously retouched (edited). No wonder: The photo had been reproduced by painting it, then photographing the painting, then making a woodcut of the photo.

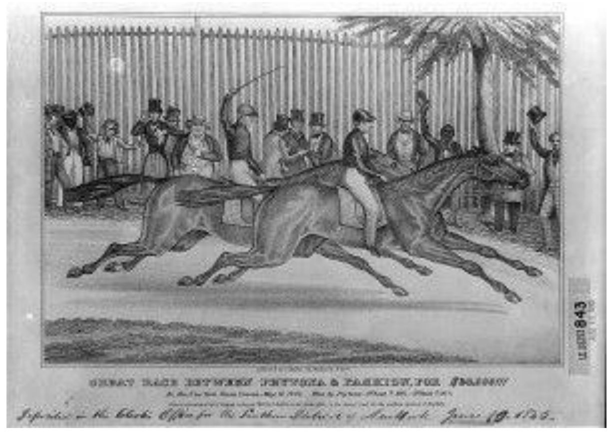
The following year, Stanford financed Muybridge's next project: to use multiple cameras to photograph a Thoroughbred at a gallop at Stanford's farm in Palo Alto on June 15, 1878 in the presence of the press.





Muybridge continued his labors, with the engineering help of Stanford's Central Pacific Railroad. They installed 12 evenly spaced trip wires on Stanford's Palo Alto racetrack. When a horse pulled a two-wheeled sulky carriage over the wire, the wheels pushed the wire down, pulling a switch that opened an a rapid-fire sliding shutter mechanism in the side of a purpose-built shed. Inside the shed, behind a row of 12 shutters, was a row of 12 cameras. As a backup, each camera had two lenses and made two separate exposures/pictures. If both came out, Muybridge selected the clearest image. Opposite the shack was a white wall with vertical lines matching the trip wires and cameras every 21 inches, which would help him be able to put the photographs in the proper order, once they had been made and developed.

So, on June 15, 1878, before assembled gentlemen of the press, Stanford's top trainer drove Stanford's top trotter across the trip wires at about 40 feet per second, setting of all 12 cameras in rapid succession in less than half a second.



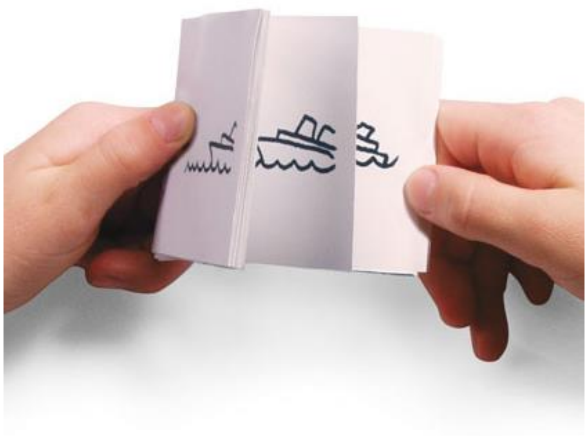
About 20 minutes later, Muybridge showed the freshly developed photographic plates. The horse, indeed, lifted all four legs off the ground during its stride. Remarkably, this was not in the front-and-rear-extended "rocking-horse posture" some had expected and many artists used (see image), but in a tucked posture, with all four feet *under* the horse.

See the animated series of Sallie Gardner running at http://upload.wikimedia.org/wikipedia/commons/d/dd/Muybridge_race_horse_animated.gif

Stanford was vindicated, the press astounded, and — as word spread — the art world was split. Painters Edgar Degas and Thomas Eakins loved the realism and used Muybridge's photos to move their own work closer to reality. But sculptor Auguste Rodin thought it an abomination (A thing that causes disgust or hatred): "It is the artist who is truthful and it is photography which lies, for in reality time does not stop," he declared furiously.

Muybridge certainly did not stop. He refined his invention, increasing the cameras from one dozen to two dozen, and developed a timer that opened shutters independently of any trip wires. That allowed him to study the motions of other four-footed animals, human athletes, birds and others. Later his book *Animal Locomotion* was finally published in November of 1887, and contained 781 plates. Muybridge had created an encyclopedic anatomy of motion, depicting humans and animals in various stages of work, play, and rest. Muybridge went on to publish a series of finely printed, large-format books of his stop-motion photographs with horses, goats, cats, gnus, eagles, gazelles, sloths, camels, many others shown walking, running, flying, leaping, and more. His books are still used as references for animators, artists, and others today. **Show students *Animals in Motion* by Eadweard Muybridge.**

Flip Out! Images in Motion



Muybridge also adapted the zoetrope, a popular children's toy that produced the illusion of motion by spinning a series of animation-style drawings behind a viewing slit. The "zoopraxiscope" as it was called created the first photographic motion pictures, and it was a hit with Stanford and children. Soon, however, Thomas Edison and the Lumière brothers took Muybridge's proof of concept and gave birth to movies as a commercial art form and his work eventually led to the development of motion pictures as we know them today.

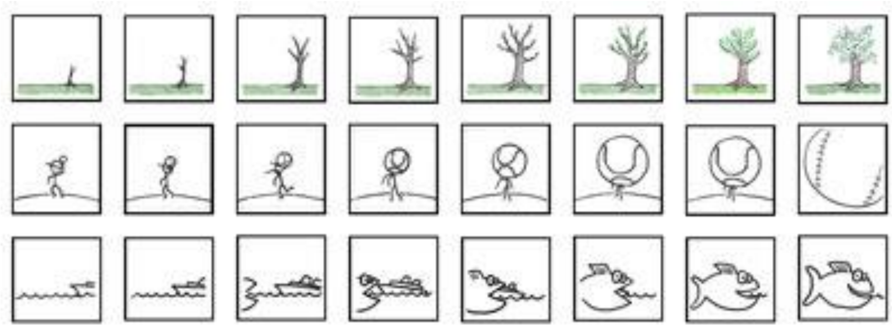
Most of us remember being shown a flipbook as children. Flipbooks work so that, when the pages are "flipped" through, it appears that an image on the page is actually moving, like in Muybridge's zoopraxiscope. A series of still pictures viewed in quick succession creates the illusion of movement, whether it is actors dancing across the silver screen, a horse galloping, a tree growing, a rocket taking off, a cat chasing a dog, a volcano, someone dancing with their mp3 player, a fish getting caught on a line, or a man running on paper. Option: Introduce the topic with a fun book such as *Gallop!: A Scanimation Picture Book*, a high tech version of a flip book, in which he black-and-white images openly reference the motion photography of Eadweard Muybridge (an influence that Seder acknowledges on the copyright page).

Materials

- Post-it notes, index cards, or an old paperback with wide margins
- Pencil
- Markers or other drawing tools

1. Have students look at a terrific example of a simple animation in motion, and explain the idea to them aloud.
2. Ask students to think of a simple movement that they would like to portray, such as
    - A boy doing jumping jacks?
    - Two people running toward each other?
    - A cat chasing a bird?
    - An erupting volcano?

3. Provide students with small pads of paper (or a pile of sheets of paper, all the same size, which they can tape or staple together at the top to make a pad) to use as their "film." Students will need at least 25 pages for their flip book. The more pages they have, the nicer it will be, so don't be afraid to encourage them to go for 40 or 50 pages. The pages don't have to be large. Small strips or squares are best. You want something that is easy to hold in their hand and flip with their thumb.



4. Small pre-purchased notepads and notebooks can be great for flip books. Sticky note pads in the traditional two inch square size are perfect. And as a plus, they can be easily taken apart and re-aligned together. If you don't have little note pads, you'll have to cut small pieces to size.
5. To make a picture look like it's moving, it's necessary to draw the same thing, but with a little change on each page to indicate the movement. Ask students to start with the very beginning image, and plan its movement, but to draw the movement in small additions, one page at a time. Beginners should keep things simple. Stick figures, ants, or bouncing balls can all be worthy flip-book stars.
6. Remind students to draw their scenes as close to the unbound edge as possible so the action is easy to see when the pages are flipped.
7. Tip: When drawing, push down hard with your pencil to create an indentation on the next frame. Use this as a guide to help you reproduce parts of your movie that don't change, like background scenery.
8. Make gradual changes from frame to frame. The more similar each frame is to the previous, the smoother the action in the final movie. (To tell a long story, some people use the margins of an old paperback so they'll have hundreds of frames to work with.)
9. Tell students to keep drawing until the movement is complete. Ideally, there should be some twist to your story to give it drama, as in the very very abbreviated samples shown
10. Once the "story" is mapped out, ask students to thumb-flip the pad forward and backward to show their own mini-movies.

Now, If a picture speaks a thousand words, surely students can come up with a few of their own in this hilarious game of which player wrote which caption. Have students write a complete sentence or sentences, grammatically correct, come up with their own punch line/quip for a flip book. Show students a flip book as a group. Then choose a guesser and a reader, or the Teacher may be the reader.

1. Everyone but the "guesser" makes up a caption for the cartoon & gives it to the "reader" Give students a limited time frame to write their own grammatically correct punch line/quip. It's not always easy, which of course is what makes it worthwhile and fun. **Emphasize skills that are appropriate to each grade level and skill level of students in your group. As needed stop the game to cover the skills that students are struggling with [ex. punctuation, action verbs, tenses], this may require small breakouts session or pre-teaching before the game with short review during the game.**
2. Have students peer edit and have the Reader/Teacher check each entry as it is submitted, students may need to go back and edit their sentences for correctness before they can be submitted.
3. Once all entries are in, the "reader" reads them silently first & then shuffles them & reads them to the "guesser."
4. The "guesser" picks his/her 3 favorite captions & ranks them accordingly
5. The "guesser" tries to guess who wrote each of the 3 favorites.
6. The person whose caption was rated first place moves gets 3 points, 2nd gets 2 points, 3rd gets 1 point. For each one the "guesser" guessed correctly the "guesser" gets a point (for a max of 3 spaces)
7. The "guesser" & "reader" rotate each turn, unless the reader is the teacher. Also, choose a new flipbook for each round.
   With over 10 people choose, 1st 2nd and 3rd, however if you are playing with less people the "guesser" might only want to choose their 2 favorites.

Sources and Resources

This lesson plan is a small window into the vastly intricate world of Cameras and Photography. We hope it will stimulate further exploration into the world of Photography by students, and instructors, into the world of experts in the field, expand our view of the world, make students laugh, and make them think, make us more observant, and stimulate our imaginations. In the construction of this lesson plan we have been guided by, and recommend the following resources among many others:

- http://ngm.nationalgeographic.com/2011/05/camera-obscura/oneill-text
- http://fi.edu/pieces/myers/camera_obscura.html
- http://www.exploratorium.edu/science_explorer/pringles_pinhole.html
- http://en.wikipedia.org/wiki/Film_base
- What Is the Difference Between Reverse Engineering and Re-Engineering? | eHow.com http://www.ehow.com/info_8423735_difference-between-reverse-engineering-reengineering.html#ixzz2Ahb0aiWm
- http://www.exploratorium.edu/light_walk/lw_todo.html
- http://www.arborsci.com/cool/lab-27-6-light-pinhole-image
- http://jovasquez.blogspot.com/2010/08/bioluminecence-light-produced-by-living.html
- http://www.ehow.com/how_12099901_make-running-person-flipbook.html
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- http://www.stevespanglerscience.com/experiment/sun-sensitive-paper-experiment
- http://mrlsmath.com/wp-content/uploads/2008/01/backwards-math-from-number-sense.pdf
- Grammar Tense Games | eHow.com http://www.ehow.com/info_7880113_grammar-tense-games.html#ixzz2BYKYqX00
- Past-Tense Classroom Grammar Games | eHow.com http://www.ehow.com/info_8171534_pasttense-classroom-grammar-games.html#ixzz2BYbmCzHE