Lesson Focus
Using vector-based graphic design software and an Epilog Laser cutter/engraver, students will learn to design and produce their very own custom backpack/luggage tag.

Age Levels
+ 9 - 14

Objectives
Introduce students to:
+ How CO2 laser cutters/engravers work.
+ Recognizing laser compatible materials.
+ Basic graphic design concepts necessary to successfully design for laser engraving and cutting.

Anticipated Learner Outcomes
Students will be able to
+ Create simple raster and vector designs to create real-world products with the laser.

Internet Connections
+ https://youtube.com/epiloglaser (videos of Epilog Laser cutters/engravers in action)
+ https://www.epiloglaser.com/resources/sample-club.htm/

Recommended Reading
+ Epilog Laser User Manual
+ Epilog Laser Safety Manual (Appended to this document)

Optional Writing Activity
+ Now that you understand how laser cutter/engravers work, how many everyday items around you do you see that could have been engraved or cut with a laser?
+ After performing this project, what other types of projects do you think could be completed with a laser?
Laser Creations
Teacher Resource:

Anticipated Learner Outcomes
Students will be able to:
Understand how laser engraving/cutting systems work, as well as common laser-friendly materials. Students will be able to utilize graphic design software to create simple engraving/cutting projects.

Materials
- Epilog Laser cutter/engraver.
- Windows vector-based graphic design software. For the purpose of this lesson plan we will be using CorelDRAW. (Free trial version can be downloaded at: https://www.coreldraw.com/en/pages/free-download/)
- Wood strips. For the purpose of this project, we will be using 14” x 4.5” sheet of alder that are approximately 1/8” thick.

Procedure
1. Before the lesson, gauge how many students have ever used a laser cutter before, and which ones have any experience with graphic design software.
2. Using the teacher resources below, educate students on how a laser cutter works and what materials it is capable of engraving and cutting.
3. Prior to executing the project, discuss with students how the laser recognizes raster and vector lines within design software. (Included in teacher resources below.)
4. Utilizing the student worksheet, walk students through steps of creating a custom backpack/luggage tag.

How a laser works & compatible materials:
Epilog’s CO2 lasers are types of gas lasers. In CO2 cutting/engraving systems, electricity is run through a gas-filled tube, which is located at the back of the machine. Generally, the gases in the tube include a mixture of carbon dioxide, nitrogen, hydrogen, and helium. When electricity is run through this tube, a light is produced. The light that is created is powerful enough to cut through many materials, including wood, acrylic, fabrics/textiles, rubber, paper/cardstock, and much more. The light from a CO2 laser cutter/engraver can also etch/engrave – but not cut – harder materials such as slate, glass, stone, and coated metals.

Laser cutters are computer controlled, meaning the user tells the laser what to do by manipulating artwork, and providing specific engraving or cutting instructions through the print driver. Laser applications are generally broken into two categories: raster engraving and vector cutting. The student project provided below incorporates both engraving and cutting applications.

Raster Engraving
Raster engraving can best be described as very high resolution dot matrix “printing” with a laser. Raster engraving is used to create highly detailed graphic images. The laser head scans back and forth, left to right, engraving a series of dots one line at a time. As the laser head moves down line by line, the dot pattern forms the image that was printed from your computer. You can raster engrave scanned images, text, clipart, photographs, or line drawings.
This artwork is a good representation of a raster file. The photograph of the tiger will raster engrave, as will the text that has been placed on the page.
Vector Cutting:
When you are vector cutting, the laser is following a continuous path that follows the outline, or profile, of an image or text. Vector cutting is normally used to cut completely through materials such as wood, acrylic, paper, etc. It can also be used for quick marking of characters and geometric patterns. You can vector cut with the laser by setting objects and text to be unfilled and drawn with a 0.001” (0.025 mm) outline. The thin outline will produce a vector cut.

The graphic above shows a vector image made up of lines. You can tell it is a vector image because you can individually select any of the lines and manipulate that part of the graphic.

The laser determines which lines to engrave or cut based on the width (stroke) of each line. If you’re using CorelDRAW, any line set to hairline width will cut. But if you are using different software, the table below outlines what weights will engrave and cut at different widths and resolutions.

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<th>Line Width</th>
<th>150 DPI</th>
<th>200 DPI</th>
<th>300 DPI</th>
<th>400 DPI</th>
<th>600 DPI</th>
<th>1200 DPI</th>
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</tr>
</tbody>
</table>
**Laser Creations**

**Student Resource:**

The best way to describe how CO2 laser cutter/engravers work is to compare the system to your printer. Using similar technology, a laser cutter/engraver takes the images you typically print to paper, but instead of ink, a CO2 laser beam is fired, and that beam actually burns the image you select to etch/engrave, or cut.

The laser recognizes images, graphics, text, and lines, and through your graphic design software and print driver, you instruct the laser on which items to engrave, and which ones you want to cut.

The laser works in three different modes: raster, vector, and combined.

**Raster Mode:** We use raster mode when we want to engrave or etch. Most users engrave clipart, scanned images, photos, text, and graphic images.

**Vector Mode:** Use vector mode when you are cutting lines. In vector mode, a line is recognized as a line to be cut based on the line width (or stroke). To make things easy, set any cut lines to a line width of 0.001” (.0254 mm), or hairline width in CorelDRAW. Vector lines that you want to engrave rather than cut should be set 0.006” (0.152 mm) or greater line thickness.

**Combined Mode:** Use this setting when you engrave and cut in the same job. The laser will always engrave first, and then follow with the vector cutting path.

Let’s start with a simple project – a wooden identification tag you can adhere to your backpack or luggage. Use the student worksheet to walk you through the steps of designing your custom tag and using the laser to engrave and cut it!
Laser Creations

Student Worksheet:
Open a new file in CorelDRAW.

Under “page size”, enter the size of the wood plank you will be working with. For the purposes of this tutorial, we used 14” x 4.5”, but your page size may be different.
Using the Rectangle Tool, draw your luggage tag – we suggest a size of 2” x 4” or 3” x 5”, depending on the size of your wood plank.
Make sure your tag is set to a line weight of “hairline.”
We need to add a circle cut-out that will allow you to place a ring or string to attach the tag to your bag. Use the Ellipse Tool to create a small hole – about ¼” in diameter. Remember to change the outline to “hairline” so it will cut out.
After you’ve drawn your square tag and cut-out hole, use the text tool to enter the contact information you want to include, such as your name and email address.
Select your font and size to best fit on the tag.
When you’re ready to engrave and cut your tag, hit “CTRL P” and send your job to the laser. When the print driver pops up, change the piece size to match what you entered in CorelDRAW. Change your raster engraving settings and vector cutting settings (refer to user manual for recommended settings for your wattage laser). Lastly, make sure you have “combined mode” selected in the print driver, since you want to both engrave and cut.
When the job reaches the laser, press the green “GO” button and your tag will be made. After you’ve created your own tag with the instructions above, experiment with different shapes, text, and fonts to create a new tag for a friend or family member!
Laser Creations

Teacher Resource: Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Computer Science Teachers Association K-12 Computer Science Standards, the U.S. Common Core State Standards for Mathematics, and if applicable also to the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics, the International Technology Education Association's Standards for Technological Literacy, and the U.S. National Science Education Standards which were produced by the National Research Council.

◆ Next Generation Science Standards & Practices Grades 6-8 (ages 11-14)
  Practice 5: Using Mathematics and Computational Thinking
  ✦ Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.

◆ Next Generation Science Standards & Practices Grades 6-8 (ages 11-14)
  Practice 5: Using Mathematics and Computational Thinking
  ✦ Use mathematical representations to describe and/or support scientific conclusions and design solutions.

◆ Common Core State Practices & Standards for School Mathematics (all ages)
  ✦ CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
  CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.

◆ Standards for Technological Literacy - All Ages
  Nature of Technology
  ✦ Standard 2: Students will develop an understanding of the core concepts of technology
  The Designed World
  ✦ Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies

◆ CSTA K-12 Computer Science Standards Grades 6-9 (ages 11-14)
  5. 2 Level 2: Computer Science and Community (L2)
  ✦ Computing Practice & Programming (CPP)
    2. Use a variety of multimedia tools and peripherals to support personal productivity and learning throughout the curriculum.

◆ CSTA K-12 Computer Science Standards Grades 9-12 (ages 14-18)
  5.3 Level 3: Applying Concepts and Creating Real-World Solutions (L3)
  5.3.B Computer Science Concepts and Practices (CP)
  ✦ Computing Practice and Programming (CPP)
    1. Use advanced tools to create digital artifacts (e.g., web design, animation, video, multimedia).
Laser Safety

The Epilog Model 8000 Laser System is a Class 2 laser product, as defined in International Standard IEC 60825-1.

The Epilog Model 8000 complies with 21 CFR 1040.10 and 1040.11, the Federal Performance Standards for Light-Emitting Products, except for deviations pursuant to Laser Notice No. 50, dated July 16, 2001. The Center for Devices and Radiological Health, of the US FDA, issued Laser Notice No. 50 to permit manufacturers to classify and manufacture their products in accordance with the International Standard.

The output of the embedded high-power CO2 engraving laser is fully contained. The laser cabinet has safety interlocks that turn the laser off if the door is opened during operation, and no special precautions are necessary to operate the high-power laser safely. However, the visible output beam of the Laser Diode Pointer (Red Dot Pointer) is accessible to the operator. While this device employs the same technology as the familiar laser pen-pointers, like them it is potentially hazardous if its beam is directed into the eye.

We have made every effort to make the Laser Diode Pointer (Red Dot Pointer) as safe as possible. Its beam path is located well inside the cabinet, and under normal conditions, no hazardous levels of laser radiation can escape.

The operator of the Epilog Model 8000 should observe the following general precautions:

- **DO NOT** disassemble the machine or remove any of its protective covers while the unit is plugged in.
- **DO NOT** attempt to defeat the door interlocks.
- **DO NOT** view directly into the beam of the Laser Diode Pointer (Red Dot Pointer).
- **DO NOT** operate the Laser Diode Pointer (Red Dot Pointer) without the machine's focus lens in place. If the unfocused beam strikes a reflective surface, it could be directed out of the cabinet.
- **Caution** – Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.
The standard reference for laser safety is the American Standard for the Safe Use of Lasers, Z136.1-2000, developed by the American National Standards Institute (ANSI). This reference is the basis for many of the federal regulations for laser and laser system manufacturers, and for the Occupational Safety and Health Administration (OSHA) laser safety guidelines. It contains detailed information concerning proper installation and use of laser systems.

While the ANSI standard itself does not have the force of law, its recommendations, including warning signage, training, and the designation of a laser safety officer, may be compulsory under local workplace regulations when operating laser systems above Class I. It is the operator’s responsibility to ensure that the installation and operation of the Epilog Model 8000 Laser System is performed in accordance with all applicable laws. Copies of ANSI Standard Z136.1-2000 are available from Epilog Corporation or from:

Laser Institute of America
12424 Research Parkway, Suite 125
Orlando, FL 32826
(407) 380-1553

**Electrical Safety**

The AC input power to the Epilog Model 8000 Laser System is potentially lethal and is fully contained within the cabinet.

- **DO NOT** open any of the machine’s access panels while the unit is plugged in. Opening a panel may expose the operator to the unit’s AC input power.

- **DO NOT** make or break any electrical connections to the system while the unit is turned on.
Fire Warning

Didn’t you see this already? Yes! That’s how important we think it is for you to read this information.

Your laser system uses a high intensity beam of light that can generate extremely high temperatures when it comes into contact with the material being engraved, marked or cut. Some materials are extremely flammable and can easily ignite and burst into open flame setting the machine afire. This open flame is very dangerous and has the potential to destroy not only the machine, but the building in which it is housed.

Experience shows that vector cutting with the laser has the most potential to create an open flame. Many materials are susceptible to igniting, but acrylic, in all its different forms, has been shown to be especially flammable when vector cutting with the laser.

Please read the following warnings and recommendations and follow them closely at all times!

- **Stay with the laser.** Never operate the laser system while unattended.

- **Keep the area clear.** Clean around the machine and keep the area free of clutter, combustible materials, explosives, or volatile solvents such as acetone, alcohol, or gasoline.

- **Be prepared with a fire extinguisher.** Always keep a properly maintained and inspected fire extinguisher on hand. Epilog recommends a Halotron fire extinguisher or a multi-purpose dry chemical fire extinguisher. The Halotron extinguishers are more expensive than a dry chemical, but offer certain advantages should you ever need to use an extinguisher. The Halotron extinguisher discharges a clean, easily removable substance that is not harmful to the mechanics or wiring of the laser system. The dry chemical extinguisher discharges a sticky, corrosive powder that is very difficult to clean up.

- **Use Air Assist.** Always use the system’s Air Assist feature when vector cutting.

- **Use caution when vector cutting.** Many materials have the potential to suddenly burst into flames when cut with a laser – even materials that may be very familiar to the user. Always monitor the machine when it is operating.

- **Clean the laser.** A buildup of cutting and engraving residue and debris is dangerous and can create a fire hazard in its own right. Keep your laser system clean and free of debris. Regularly remove the Vector Cutting Table to clean any small pieces that have fallen through the grid.
Safety Features and Regulatory Compliance

Epilog has incorporated specific safety features into the Model 8000 Laser System in order to meet the requirements of 21 CFR 1040 and the International Standard IEC 60825-1. These safety features include:

- A safety enclosure (cabinet), which fully encloses the engraving laser and its beam path.
- Dual redundant interlock systems that turn off the engraving laser when the window is opened.
- A visible emission indication when the Laser Diode Pointer (Red Dot Pointer) is operating. There is an LED indicator on the machine's front panel.

21 CFR 1040 and IEC 60825-1 require that certification, identification, and warning labels be placed on laser products. Reproductions of labels on the Epilog Model 8000 Laser System follow, with their locations specified:

1. **Certification/Identification Plate:** This engraved plate is located on the left rear of the machine's cabinet.

   ![Certification/Identification Plate](image)

2. **Warning Logotype:** This label is located on the left rear of the machine's cabinet, below the Certification/Identification plate.

   ![Warning Logotype](image)
3. **Descriptive Label:** This label identifies the classification of the Model 8000 in accordance with 21 CFR 1040.10 and IEC 60825-1. It is located on the rear of the machine's cabinet, beside the Warning Logotype.

4. **Non-interlocked Protective Housing Safety Labels (4):** Two of these labels are located on the rear of the machine beside the edges of each of the cabinet's end covers. The other two are located on the cabinet walls under the cover so they are visible when the covers have been removed.

5. **Defeatably-interlocked Protective Housing Safety Labels:** This label is located on the machine's cabinet door, in the upper left hand corner.

6. **Electrical Safety Label:** This label is located on the access panel on the rear of the machine's cabinet.

7. **Fire Safety Label:** This label is located on the machine's cabinet door in the upper right hand corner.

8. **Aperture Safety Label:** This label is located on the steering mirror cover inside the machine's cabinet, beside the aperture where the laser beams enter the cabinet.

9. **Fire Warning Label:** There are two labels on top of the machine's cabinet; one to the left and one to the right of the top cabinet door.
Do's and Don'ts

Don’ts

Do Not Run the Laser Unvented: Never operate the machine without a properly operating vent to the outside or to a filtration unit! Most material will only produce an irritating smoke when engraved. Some materials, including but not limited to paint, varnish, composition board and plastics, produce compounds that can be harmful if concentrated. A properly installed vent is the only way to ensure that problems do not occur.

Do Not Engrave or Cut PVC: Never engrave or cut any material containing PVC or vinyl. When engraved, a corrosive agent is produced that will destroy your machine. Your warranty will be void if your machine is damaged by corrosion from engraving or cutting PVC or Vinyl.

Do Not Operate Machine While Unattended: Never operate your machine without someone watching the system. There is a significant risk of fire if the machine is set improperly, or if the machine should experience a mechanical or electrical failure while operating.

Do Not Vector Cut While Machine Is Unattended: Never laser cut any material with the laser without someone watching the system. Because vector cutting moves relatively slowly compared to raster engraving, a tremendous amount of heat is applied to the material being cut. This buildup of heat can cause significant fire risk and the machine should always be monitored. Additionally, the Air Assist should always be turned on when vector cutting to reduce the risk of fire.

Do Not Operate The System While Doors are Open: Never operate with any of the covers or enclosures removed, and never modify the enclosure. The laser beam is invisible and is very dangerous!

Do’s

Clean the System: Please allow a few minutes a week for cleaning your machine. Just a small amount of effort at the end of the week will pay off with years of trouble free operation of your machine.

See the “Section : Cleaning & Maintenance” on page 65 for specifics.