Laser Lissajous

Use a laser pointer and two small rotating mirrors to create a variety of Lissajous figures.

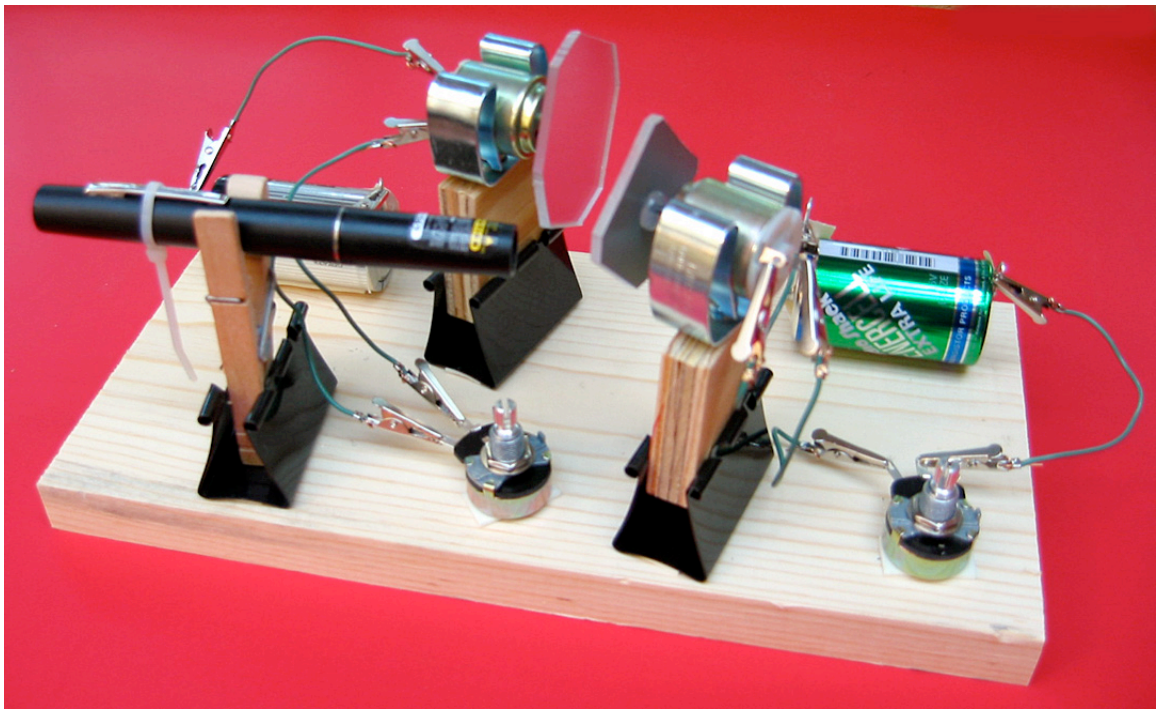

Figure 1

Materials

- laser pointer
- wood base, 3/4 in x 5 1/2 in x 11in (this is a piece of standard 1x6 pine shelving 11 inches long) -- can also use plywood -- exact size is not critical as long as all the components will fit and be functional
- 3 large binder clips
- 12 inches of double-sided foam tape, 1/2 in wide -- cut into 5 pieces 2 in long and 2 pieces 1 in long
- 2 pieces plywood, 1/2 in x 2 1/2 in x 1 1/2 in -- lower corners may be cut off (See Figures 4 and 5)
- 2 spring grip broom clips -- available at Home Depot and True Value Hardware
- 2 motors, 1.5-3 volt -- Kelvin 850647 or Radio Shack 273-223 -- Kelvin cheaper
- 2 potentiometers, 20 or 25 ohm -- Mouser 313-2401-20 or Radio Shack 271-265
- mirror, plastic (plexi-mirror) 1 1/2 in x 1 1/2 in
- mirror, plastic (plexi-mirror) 2 in x 2 in
- 2 screws, sheet metal, #8 x 5/8 in, pan head, Phillips
- 12 alligator clips -- Radio Shack 270-380
- 3 ft copper wire, #22, insulated, solid -- cut into 6 pieces 6 in long
- clothespin, wood, with spring
- hot glue gun
- hot glue sticks
- electric drill
- 7/64 in drill bit
- 2 washers, steel, SAE #8
- 2 batteries, D
- needle-nose pliers
- masking tape
- screw driver, Phillips
- wire stripper

Use of OPTIONAL items below is noted in Assembly instructions.

- 6 sheet metal screws, #10 x 1/2 in, pan head, Phillips (OPTIONAL)
- 12 nails, bright finishing, 1 1/2 in (OPTIONAL)
- 2 knobs for potentiometers (OPTIONAL)
- 5/64 in drill bit (OPTIONAL)
- hammer (OPTIONAL)
- cable tie, approx 8in (OPTIONAL)

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Assembly

1. Use masking tape to tape a paper clip to each end of each battery to serve as electrical contacts. See Figure 2.

Figure 2 

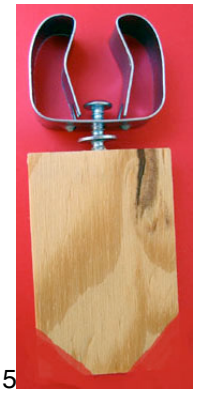
Figure 3 

2. Stick a 2 in piece of foam tape on the bottom of each of the two batteries, and then remove the backing material. Place the batteries on the base in the approximate positions shown in Figures 1 and 6. NOTE: For a more robust permanent mounting of the batteries, use 6 nails for each battery to make a battery holder as shown in Figure 3. If you are going to use the nails, it is preferable to do the hammering at this point, rather than after other components are installed.

3. Drill a 7/64 in diameter hole about 3/4 in deep into the middle of the top of each of the two wooden motor mount pieces. NOTE: The wooden motor mount pieces can be used as rectangular pieces, or the lower corners can be cut off as shown in Figures 4 and 5 -- this increases the ability to adjust the position of the mount, but either shape will work.

4. Screw a broom clip and washer onto each motor mount. The washer should be underneath the clip, between the clip and the wood. See Figures 4 and 5. Make the screw tight enough so that the spring clip is held firmly in place but can still be turned by exerting a reasonable force.

Figure 4 

Figure 5 

5. Put a raisin-size puddle of hot glue in the middle of the **back** side of one of the mirrors (try to let the puddle remain as tall as possible -- don't try to spread it out). Before the glue solidifies, place the motor shaft almost straight into the puddle. Then hold it as steady as possible until the glue solidifies. The motor shaft should be slightly off of perpendicular to the mirror. -- NOTE: If desired, you can drill a 5/64 in hole in the middle of the mirror at a very slight angle, put the puddle of glue on the back side right over the hole, put the motor shaft into the hole, and hold the motor while the glue solidifies. But remember that the motor shaft should not be exactly perpendicular to the mirror. Using the hole may give a stronger mounting for the mirror, but the mirror seems to hold reasonably well without it. Repeat the process for the second mirror.

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6. Place both motor/mirror assemblies into broom clips, and put the two complete motor mount assemblies (motor, broom clip, wood motor mount) into binder clips.

7. Place the laser pointer in the clothespin, and then put the clothespin into the remaining binder clip.

8. Remove the handles from all three binder clips.

9. Stick a 2 in piece of foam tape on the bottom of each of the three binder clips, and then remove the backing material. Place the clips on the base in the approximate positions shown in Figures 1 and 6.

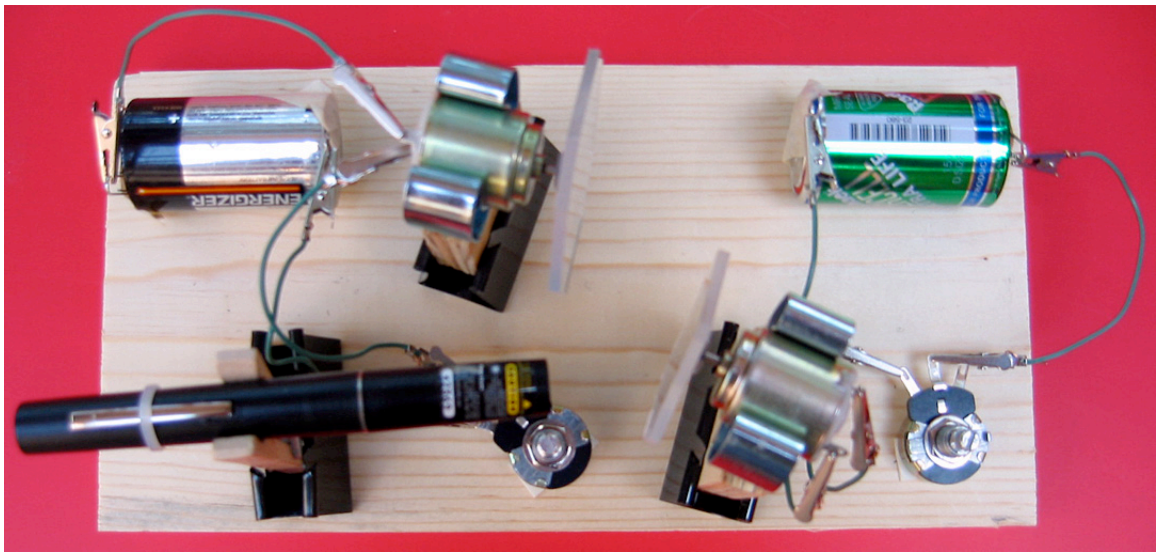

Figure 6

NOTE: Normally the tape holds reasonably well, but if it gets pulled off or is wiggled, it may not stick well. For a more robust and permanent way to hold the binder clips in place, you can also place a screw at the end of the binder clip, so that the flange of the screw head holds the binder clip down. See Figure 7.

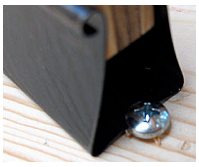

Figure 7

10. Stick a 1 in piece of foam tape on the bottom of each of the two potentiometers, and then remove the backing material. Place the potentiometers on the base in the approximate positions shown in Figures 1 and 6. NOTE: If you wish, you can buy knobs for the potentiometers. The knobs make the potentiometers a little easier to adjust.

11. Use a wire stripper to remove the insulation on the ends of the 6 wires.

12. Use needle-nose pliers to attach an alligator clip to each end of each wire. Figures 8 a-d show a sequence for one way to attach the clip securely.

Figure 8a
Stick bare end of wire down through hole.

Figure 8b
Bend bare end back and upward, between tabs.

Figure 8c
Bend near tab down to fasten bare wire against insulated wire.

Figure 8d
Bend far tab down tightly over near tab.

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13. For one of the mirrors, wire the motor, battery and potentiometer in series. Repeat for the other mirror. On the potentiometers, use the middle contact and either of the outside contacts -- to make the potentiometer shaft rotate the opposite way to turn it on, keep the middle contact but change the outside contact to the other one). To make the mirror turn in the opposite direction, reverse the leads on the motor contacts.

To Do and Notice

Turn the laser on (if the laser won't stay on by itself, you will need to improvise a way to keep it on -- a cable tie may be useful -- see Figure 1). Adjust the positions of the laser and mirrors until the laser beam bounces off the first mirror, then the second mirror, and is finally seen on a screen. If all is well, when you turn either mirror alone (either by hand or with the motor) you should see a circle on the screen. If you don't, the laser beam is missing all or part of one or both of the mirrors, or is getting blocked in some way. Make adjustments in the mirror and laser positions as necessary. Note that the spring clip can be turned to change the angle of the mirror, the wood motor mounts can be moved back and forth a little to change the position of the mirror, and the clothespin and motor mounts can be elevated a little.

Use the motors to rotate the mirrors in opposite directions (e.g., one clockwise and the other counterclockwise as observed from the same end of the device). Notice the variety of patterns (Lissajous figures) produced as you vary the speeds of the motors.

Reverse the leads on one motor so that the mirrors are now rotating in the same direction, and notice the difference in the patterns compared to the mirrors rotating in opposite directions.

What's Going On?

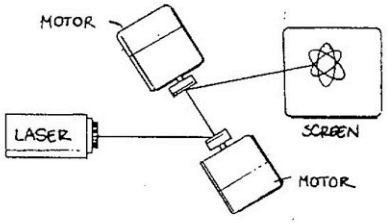
Very briefly, the Lissajous figures produced here are the resultant of two simultaneous circular motions. They are related to figures produced by a spirograph, or to the path of a rider on a dual-axis "scrambler" ride at an amusement park.

Credits and References

The basic idea for this device is a classic physics demonstration. It is shown below in a 1993-94 Metrologic Laser catalog, which contained a section with over 100 ideas for laser demonstrations (these may have been in catalogs and publications from other years as well). Metrologic sold its educational division in 2004, but if you come across a copy of an old catalog or publication with the demonstrations, it's a resource worth having.

76. Applications, Lissajous Patterns

Among the most well-known laser lighting effects are Lissajous figures, a swirling pattern of interwoven circles which have become almost a trademark of laser light shows. These intricate patterns can be created easily. Mount small mirrors on the rotor shafts of two variable speed motors. Position each mirror at a slight angle so that when the shaft rotates, a small circle is reflected. Place the laser and the two motor/mirror assemblies so that the laser beam follows a Z-shaped path, from the laser to one mirror, to the second mirror, and then to a wall or screen. If the speed of each motor can be adjusted independently, a great variety of lissajous patterns can be created.



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