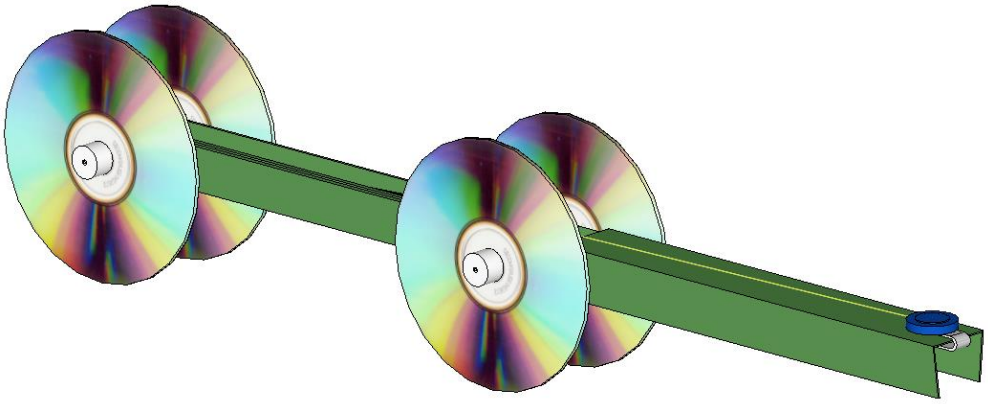
File Folder Retractor Car

Make a powered car from a file folder!



Learn about wheels, hubs, and axles, while making a vehicle that can really move!

Topics: Motion, Momentum, Friction, Simple Machines

Materials List

- ✓ Skewers, bamboo
- ✓ 2 Hanging file folders (regular letter size)
- ✓ Paper sheets, letter size, 3 sheets
- ✓ CD's, 4
- ✓ Video tape from a disassembled video tape cassette
- ✓ Badge retractor or equal, with a cord that when pulled out and released is pulled back inside
- ✓ Stapler
- ✓ Single hole punch
- ✓ Hot glue gun
- ✓ Adhesive tape or =

This activity can be used to teach:
Next Generation Science:

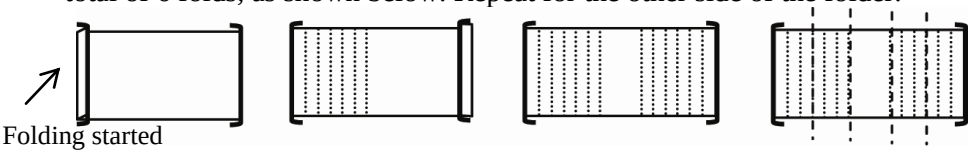
- Forces & Motion (Physical Science, Grade 3, 2-1, 2-2; Middle School, 2-2; High School, 2-1)
- Kinetic/Potential Energy (Physical Science, Grade 4, 3-1; Middle Sch., 3-1, 3-5)
- Energy can be converted (Physical Science, Grade 4, 3-4; High School, 3-3)
- Science/Engineering Pract.(Grades 2-12)

Assembly

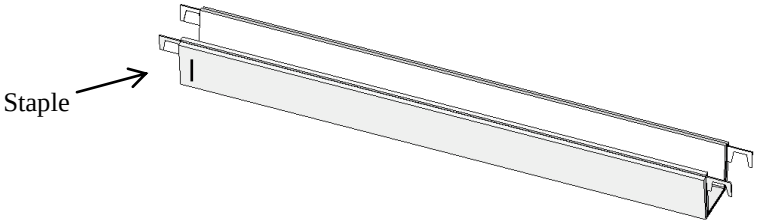
1. To make the skewers safer to handle, aim the pointed tips of the skewers toward a waste receptacle and cut off a bit of the pointed part, creating a blunt tip.

Create the Frame

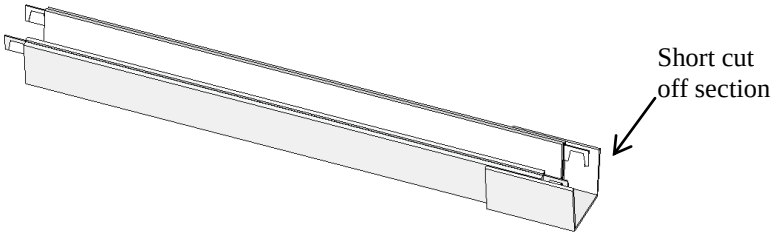
2. Open a hanging file folder. Fold where the folder becomes a single thickness – about 3 cm (1 3/16") from the metal hanger. Continue folding 5 more times for a total of 6 folds, as shown below. Repeat for the other side of the folder.



3. Turn the folder over and cut apart at the 3rd and 6th creases, counting from each end in turn as shown above in the right most illustration.
4. Crease the 4 cut off folded sections for form 4 "U" shaped channels.
5. Nest the 2 channels with the metal bars so that the metal bars are on opposite sides. Align the paper ends to one another and then staple the sides together.



6. Cut off a 5 cm (2") long segment from a remaining U-shaped channel and wrap the shorter section around the metal bar channels so there is a 3.5 cm (1.5") overlap. Staple the channels together to form the rear of the car.



Developed and written by Gus Liu (RAFT) and Michael Pollock (RAFT)
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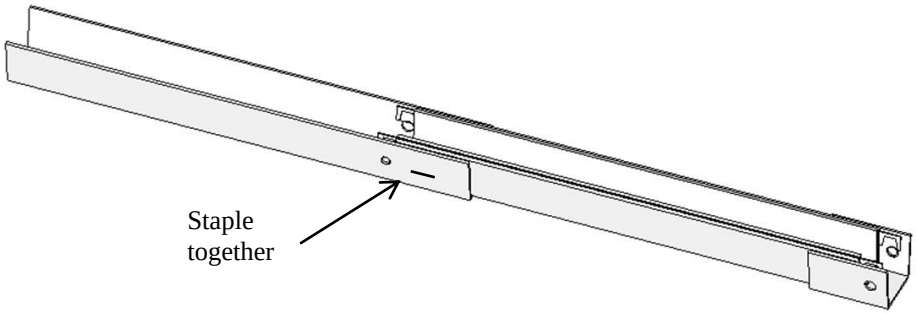
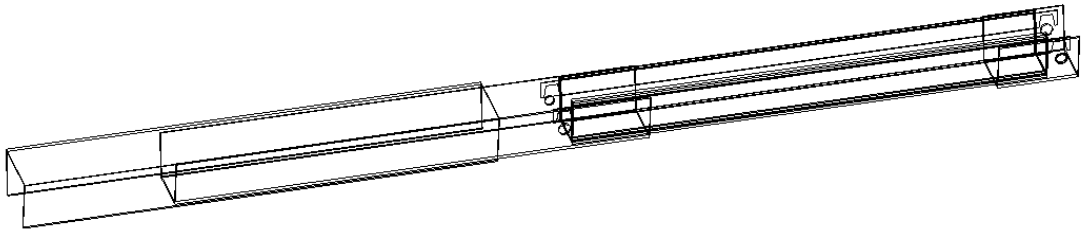
7. Wrap the remaining cut section from step 6 around the other end of the channels so there is a 3.5 cm (1.5”) or more overlap and staple the sides together to form the front of the car.



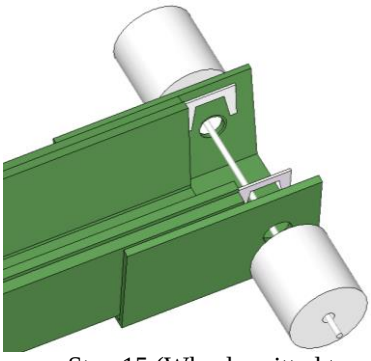
8. Punch 4 axle holes at points that are right below the 2 metal bars’ V-shaped notches. Each pair of holes should be aligned on opposite sides of the U channel.
9. Flip the last U-shaped channel so the “U” is upside down and overlap 14.5 cm (5 ¾”) with the front end of the car as shown below. Ensure that the axle holes are not covered and secure the channel to the car body with tape.



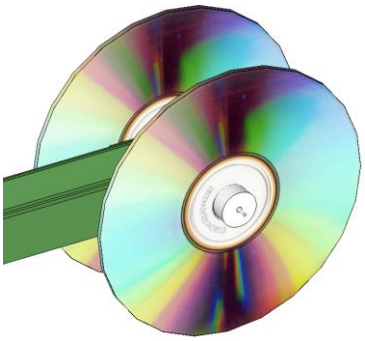
Hubs and Axles

10. Cut twenty 2.5 cm (1”) wide by 27.5 cm (11”) long strips from letter size paper.
11. Tape five of the strips end to end to make a long strip and then roll tightly around a bamboo skewer to form a wheel hub. Remove the skewer while keeping the hub tightly wound. Insert the coiled paper hub through the hole of a CD. If needed add some adhesive tape to create a tighter fit of the hub to the CD’s hole.
12. Rotate the hub to check for excessive wobble. Re-align the CD on the hub as needed to reduce any serious wobble. Apply hot glue to secure the hub to the CD.
13. Repeat steps 11 and 12 to create 4 wheel/hub combinations.
14. Insert the blunt tip of a bamboo skewer into the center of a coiled paper hub by rotating the skewer and pushing inward. Continue inserting until the hub is near the end of the skewer.
15. Insert the blunt tip into one pair of axle holes. Then insert the blunt tip into another coiled paper hub by rotating the skewer and CD. Continue inserting until both hubs are near but not touching the car body. Use hot glue to secure the hubs to the skewers. Cut off the part of the skewer that is sticking out past the hub.
16. Repeat steps 14 and 15 for the other 2 CD/hubs and the other pair of axle holes.

Step 12



Step 15 (Wheel omitted to show assembly details)



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Adding a Power Unit

17. Disassemble a video cassette and remove the reel of video tape. Cut a length of tape equal to three times the length of the car. Tie or tape one end of the video tape to the badge holder clip of a badge retractor.
18. Tape the other end of the video tape to the center of the bamboo skewer rear axle.
19. Turn or spin the rear axle to wrap the video tape around the bamboo skewer.
20. When the video tape is completely wound up, hold on to the rear axle to keep from turning, while extending the badge retractor. Clip the badge retractor to the front of the car.
21. Place the car on a smooth floor and let go of the drive axle. The car will move, powered by the stored energy in the badge retractor. If the car moves backwards then unwind the tape and rewind in the opposite direction, repeating steps 19 and 20.

To Do and Notice

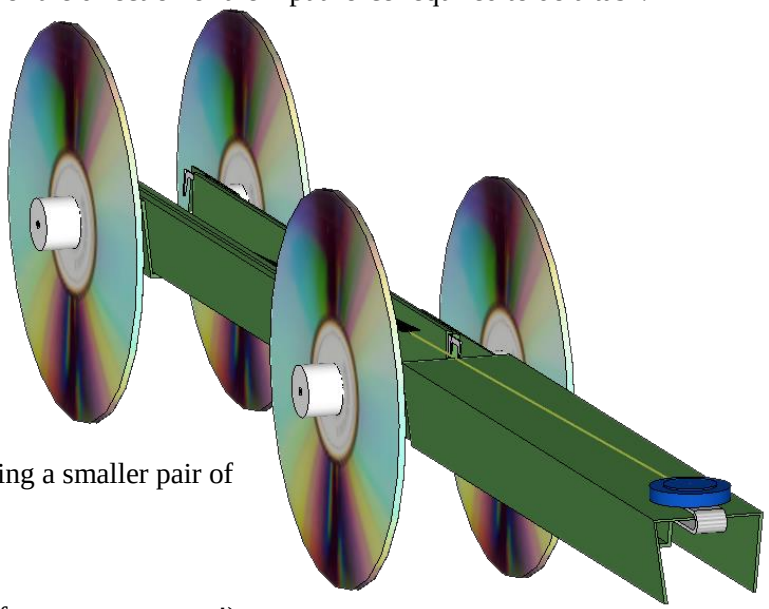
1. Place the car on a smooth floor and let go of the axle. Measure the distance travelled by the car.
2. Add weights to the car, record the car's mass, and rewind the tape as in steps 19 and 20 above and release the car. Always start the car at the same point. Compare the distances travelled.
3. How can more energy be "extracted" from the retractor? (e.g., remove slack from the wrapping of the video tape around the axle, shorten the retractor cord).

The Science Behind the Activity

A wheel and axle consists of two circular objects of different diameters, with the larger diameter wheel turning around the smaller diameter axle. A car is slowed by the rotating friction of the axles rubbing in the axle holes cut into the car body and the sliding friction between the wheels and the surface underneath. For each rotation the axle travels a shorter circular distance than the wheel. The shorter turning distance of the axle means less energy is lost to friction than if the axle and wheel had the same diameter. Many techniques have been developed to reduce the friction of the rotating axles including coating the axles with grease and adding bearings that surround the axle with even smaller rotating parts. The friction from an axle rotating in bearings is much less than the friction of an axle rotating in a hole or sleeve fixed to the car body. The wheel and axle combination is one of the six simple machines. The others are the lever, wedge, pulley, inclined plane, and screw. Simple machines can make a task easier by changing the size and/or the direction of the input force required to do a task.

Taking it Further

- Create a design challenge based on the car. Begin with the basic design, and then challenge students to make improvements by changing a design feature (e.g., multiple badge retractors, materials, dimensions, or loads).
- Explore different methods to reduce the friction of the rotating axles. Experiment with different lubricants such as soap, graphite from a pencil, or vegetable oil.
- Investigate how the distance traveled by the car is affected by changing the wheel diameters or by having a smaller pair of wheels on the front of the car.



Web Resources (Visit www.raft.net/raft-idea?isid=581 for more resources!)

- Invention of the wheel - http://www.ancient-origins.net/ancient-technology/revolutionary-invention-wheel-001713
- Designing and building a mousetrap car - http://www.pbs.org/saf/1208/teaching/teaching.htm

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