

Kinetic Structures through Lego Engineering Lesson Plan

Teaching Plan:

This project is designed to be very hands on and dependent on the children's creativity. It is more for active learners, but with the aid of multiple drawings and diagrams, reflective learners are not left out either. The goal of this project is to engineer something with moving parts out of a common material to most kids (or a nostalgic treat for high school students): legos. Although most children have worked with legos, few may have experienced the use of gears and axels, and so, a small intro (5-10min) to the materials and how they can be used will be necessary (refer to the scientific background).

The remainder of the time will be free building, with the mentors circulating around the room offering one on one help and advice. Be sure to let the kids know that they do not get to keep their lego creations and that they should not get too attached to whatever they are working on. Also, there are limited materials, so be sure they share. Judging on how much time you have at your site, leave room for 10 minutes of wrap up where each student can share their creation with the rest of the class.

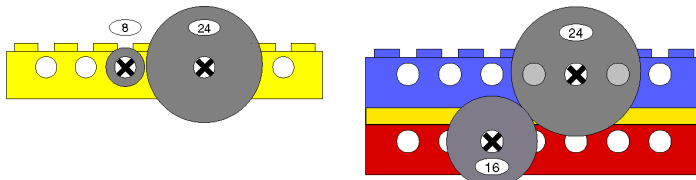
Important: Allow 10minutes at least for cleaning up. i.e. have each student take apart their lego creations and put the materials in the correct place in the kits.

Mentors Scientific Background

The main engineering concept here is gears and the transfer of motion. For elementary students use only spur gears (regular gears), and for high school introduce crown gears that allow for the transfer of vertical motion to horizontal motion.

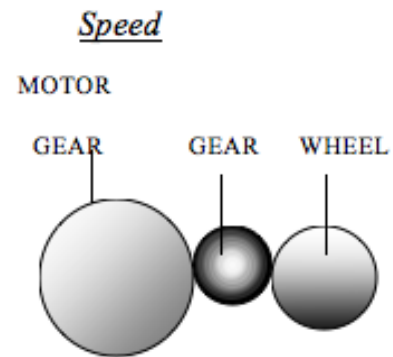
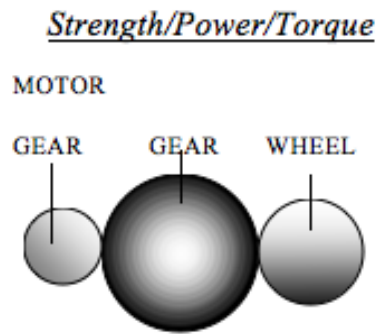
Gears have to mesh, meaning the teeth of the gears have to fit properly; too tight and they will be too hard to turn, too loose and they will grind the teeth and wear them out. Discuss with the kids why the grinding down of teeth would be bad in machines. (The teeth become smooth and won't catch onto other gears properly, meaning motion can't be transferred through that gear anymore)

When making a gear setup, you use an axle through a hole beam lego piece and then put a gear on the axle. There are these small pieces called bushings that secure the axle to the lego piece but allow for the rotation of the axle as well. Stress the importance of bushings to the kids so that pieces don't fly off.

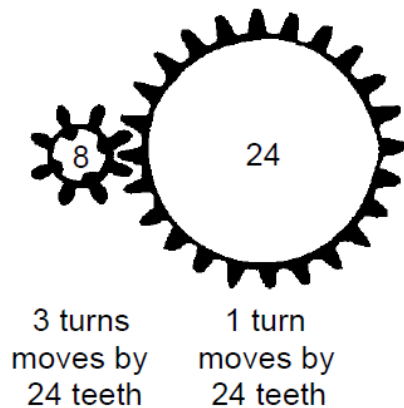


examples of how to mesh gears

You can also discuss the difference gear size make in machines. When there is a small gear being turned by a motor (or your hand through a crank), it needs to spin more than once to make a larger gear make one rotation. When the large gear is first, one of its rotations will spin a smaller gear more than one rotation. Think of the circumference differences in these cases. A small gear connected to a big gear provides a lot more power, while a large gear connected to a small gear provides more speed. Discuss with the high school students how this applies to gear shifts in cars when you need more power to go up hills ect.



3 to 1 ratio



When the 8-tooth gear rotates 3 times, it advances the meshed gear by a total of 24 teeth. Since the meshed gear has 24 teeth, it rotates exactly once. Hence this configuration produces a 3:1 ratio of gear reduction: three turns of the input gear causes one turn of the output gear.

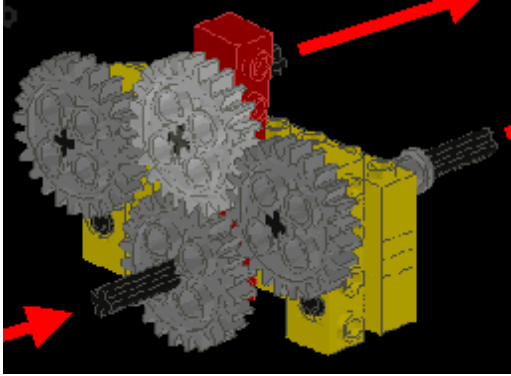
Figure 4: 3-to-1 Gear Reduction Ratio

Introduction for Mentees

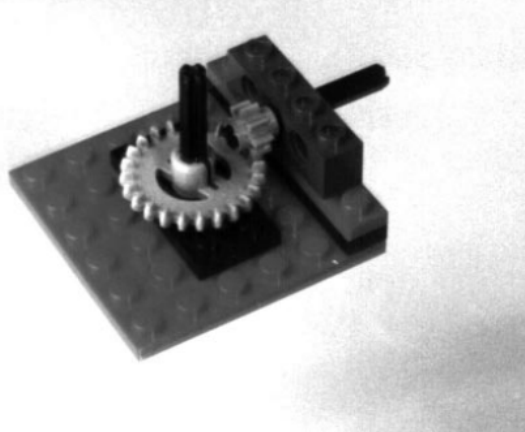
Ask a few questions to get their attention: What kind of machines use gears? (clocks, cars, music boxes, ect). Ask who likes legos. (everyone likes legos!). For the high school kids, if they don't seem as enthusiastic about legos or feel the materials are too childish, talk about lego gears and the other advance gears that make this project a real engineering challenge.

Project

Have the elementary kids make a wall of gears that mesh together. Once kids create a basic wall with gears, they can connect other lego pieces or pieces of paper (with tape only) to the axels and have them spin when they turn a different axel by the transfer of motion through the gears.



The high school kids can either create a similar set up with regular gears, or they can try to create something using a crown gear to transfer motion upwards. Two examples are carousals (connection 1 crown gear to 1 spur gear) and car differentials (more complicated).

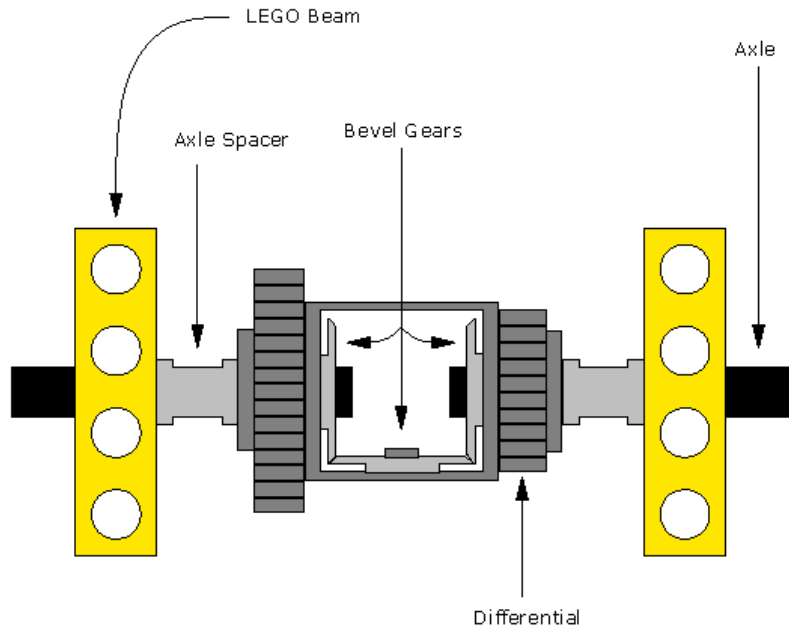


The 8-tooth gear, in conjunction with the 24-tooth *crown gear*, is used to change the axis of rotation in a gear train.

In this instance, the configuration provides for a vertical shaft output. Horizontal output also possible.

Figure 9: 8-Tooth Gear Meshing with Crown Gear

The above picture is a simple setup with a crown gear that can be used to make a carousel by attaching a lego platform on the vertical axel. You turn the horizontal axel.



Closing Activity and Discussion

With the elementary kids, gather them all and have them discuss how they constructed their machines, any problems they had, anything they learned. Be sure to leave time for the dismantling of the creations. With the high school students, discuss how the lego gears are similar to real gear systems and reinforce the difference between power and speed in gear shifting.

References/Citations

Gear tutorial: <http://sariel.pl/2009/09/gears-tutorial/>

Project pictures: <http://www.eecs.case.edu/courses/lego375/papers/artoflego.pdf>

Simple example of how lego gears mesh together

<http://www.youtube.com/watch?v=J0nbVo3oKl0&feature=related>

movie of a lego gear box simulating a car shifting gears

<http://www.youtube.com/watch?v=pJwuXJOVe1A&feature=related>