Technical Learning: Basic Engineering

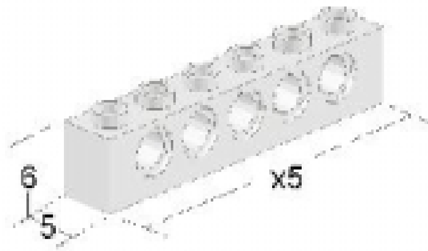
The focus of this lesson is on building solid structures. *The Art of Lego Design* by Fred G. Martin is a good introduction. It helps one go beyond the stacking of blocks to build structures capable of withstanding rolling, bumping or even crashing. To build solid structures one should understand the relationship between dimensions on LEGO blocks. Figure 1 on the next page may be used as a reference sheet. The basic relation between the height and width of a LEGO block is 6/5. The flat plates are $1/3^{rd}$ the height of a block. Those ratios allow one to use beams arranged horizontally and vertically to form interlocking structures. This could provide an excellent primer on math with fractions for your team.

Hands-on Activities

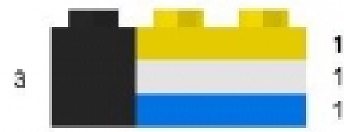
1. Explain the 4 kinds of pegs and their uses. Build a right angle with beams. Have one team build with gray pegs and two teams build with black pegs and compare to see that the black pegs are stronger.

2. Build a tight structure around the RCX unit. The two holes on either side of the RCX are there to hold pegs as additional mounting pints for vertical beams. Figure 2 shows one simple example of building a frame around the RCX. Even if you have only one Mindstorms set you may want to split your team up into two groups so each team member gets more hands-on building. While the first group builds a frame around the RCX, a second group may practice building other structures out of LEGO parts such as a cup holder, a dune buggy, a football tee, or any other structure they may think up (see Figure 3). Let them see how creative they can be.

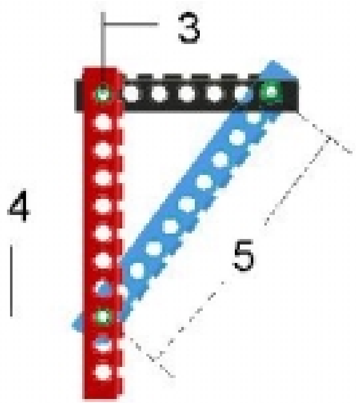
LEGO Structures



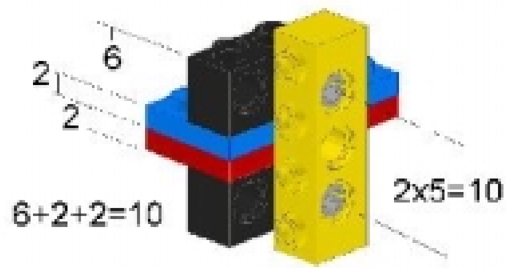
Height is 6 units relative to 5 unit width or length. Width and length run in multiples of 5 units(x5).



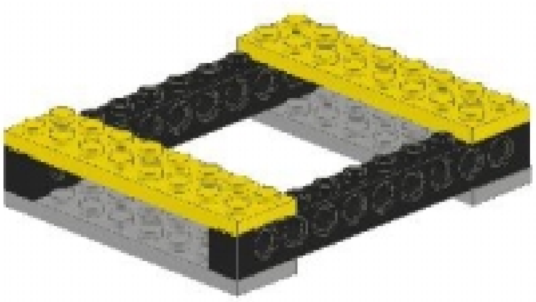
Three plates stack to same height at one beam or block.



Triangular structures formed with beams and pegs are quite strong.



The 6/5th ratio of height to width allows interlocking vertical beams with horizontal structures of the same dimension.



Here are two examples of structures, one is a box shape and the other is a beam extension using plates and pegs to tie two beams together.

Figure 1

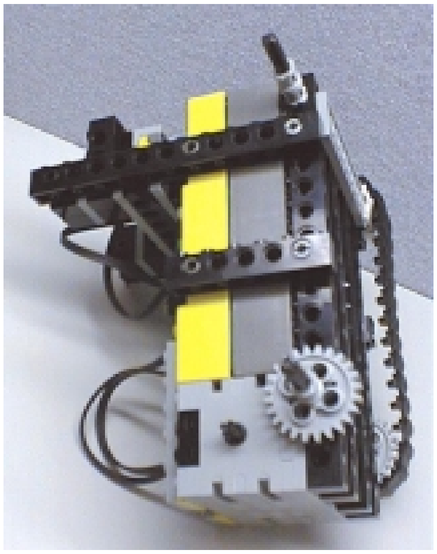


Figure 2

Figure 3

Technical Learning: Motors, Wheels and Gears

There is a trade-off between speed and torque (power) when designing a *gear train* (i.e. a series of gears driven by a single motor). The object of this lesson is for team members to understand how gearing works so that they can design a robot with speed and torque appropriate for the challenge. The motor and gear sections of *The Art of Lego Design* is a good reference.

Hands-on Activities

1. To better understand this relationship, have the groups build the gear train that is depicted on the next page. This is an extreme example of a gear train. Have each person turn each of the cranks to see and feel the gears in motion. They will see how one end produces fast motion but is difficult to turn. The other crank turns easily but produces a slower output. The RCX is not needed for this task.

2. Build the Pathfinder 2 from page 15 of the LEGO Constructopedia. Have them change from small to large wheels or change from a pulley drive to a gear drive and change the size of gears. Use the program from last weeks lesson to run the robot in a square. How does the speed of the robot change with different wheels and gears?

3. Assemble the differential gear as shown on page 10 in the Constructopedia. Build just the gear train and drive it with a hand crank. Show the effect of locking one side of the differential. This is a way to both drive a robot and steer it using only one motor. Build the rest of Robo 2 form the Constructopedia if you have time.

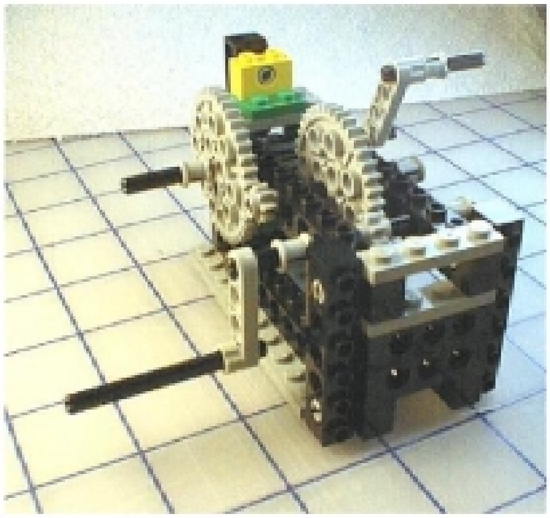
Possible Mini-Challenges

1. Make a fishing reel using a crown gear and hand crank (bring one to the meeting as a model if you plan to do this activity).

2. Make a gear train that turns like a clock with fast, medium, and slow moving arms. Use the RCX to drive the gear train.

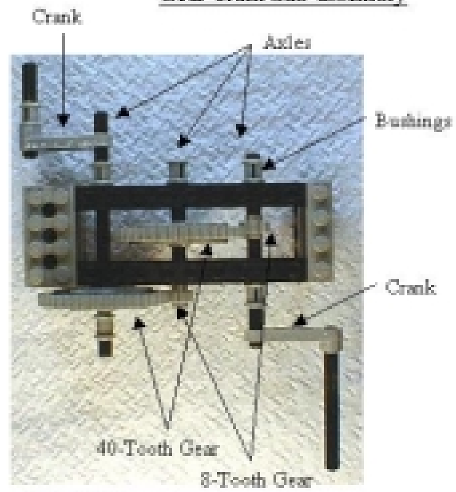
3. Attach the worm gear to a motor to drive a simple robot (hint: see Figure 7 in *The Art of Lego Design*). Program the robot to travel for a specific number of seconds. See if team members can calculate how far the robot will go. What information will they need to measure to make that calculation?

Extreme Gear Train

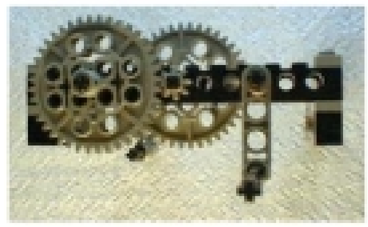


This hand turn gear train has four gears with a total gear reduction of 25:1. Build this model from the following diagrams and instructions. Then turn each crank and watch how fast the other crank spins. Also notice how hard each crank is to turn. Which one is harder to turn? Which produces a faster output?

Gear Train Sub-assembly

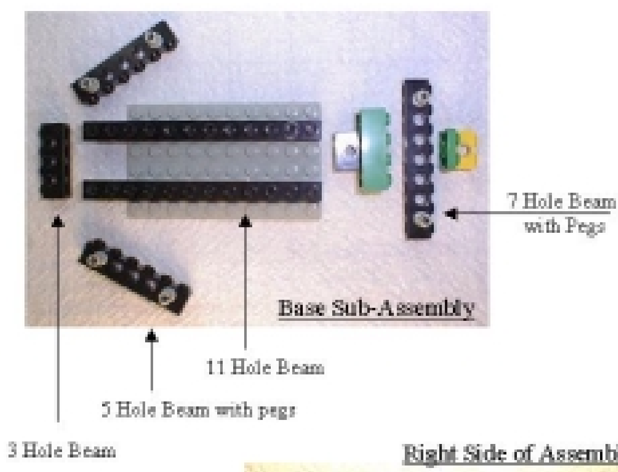


Top View



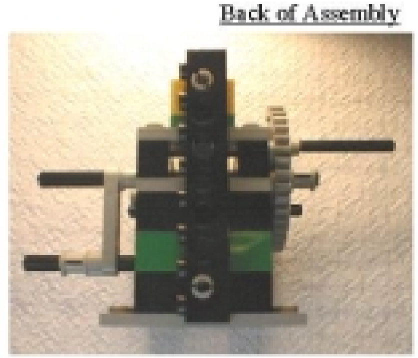
Left View

Extreme Gear Train (Continued)



Base Sub-Assembly

Back of Assembly



Right Side of Assembly

Left Side of Assembly