Using Gears, Part I

4

Gears make all the difference on a robot or machine

They are used to **slow down** or **speed up** a moving drive system, or to make a drive system **more powerful**.

The Motors used by the NXT MindStorms kit are geared motors (they already have some gears inside them). Without any load on them they turn at approximately 170 revolutions per minute (RPM). The NXT rotational sensor is accurate to within 1 degree

When we say "no load" that means the motor is just turning, it isn't making gears, wheels, axles or other parts move as well. All of these things require additional energy and will slow down the RPM output by the motor. There is also a "no-load" for a robot, this is the difference between running a robot off the ground (wheels spinning) and on the ground (moving the robot).

There is also an UNGEARED 9 volt motor. These always need gears to be useful on a robot

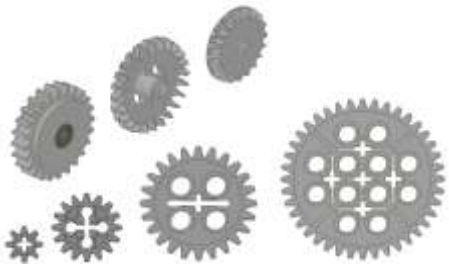
Types of Gears

The Gears used in the MindStorms kit include a number of sizes and types. The most common are:

- 8 tooth
- 16 tooth
- 24 tooth
- 40 tooth

Less common, but useful are:

- 24 tooth clutched gear
- 24 tooth crowned gear
- 20 tooth bevel gear



The last two are useful for changing axle direction and the 20 tooth bevel is used in the gear casing to make slip differentials.

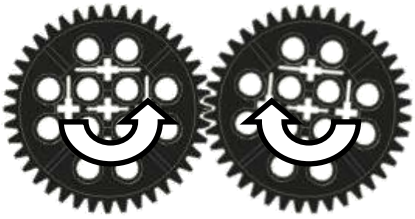
The clutch gear allows power to be transmitted from one gear to another but it STOPS this transmission (by slipping inside) so you won't damage the LEGO parts or motors.

All of the gears can be attached directly to the motor OR to an axle or connector with an axle end.

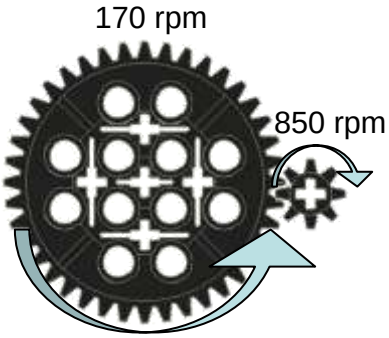
NOTE: LEGO® and MindStorms are the property of the LEGO Group

Gears can be used for a number of reasons:

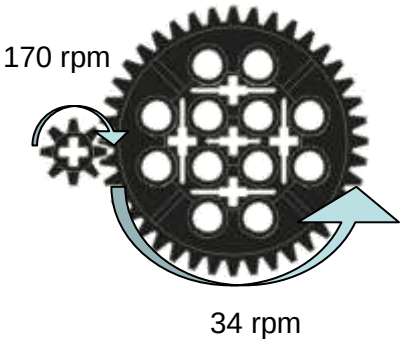
1. They can change the direction of rotation



2. They can increase the speed (decrease torque)



3. They can decrease the speed (increase torque)



4. They can change the axis of rotation

Getting more power or torque out of your robot

There are times when you need a lot of torque. Maybe you are building a robot that can pull 25 kilograms across the floor and that old "big wheel directly on the motor axle" just isn't working any more.

You can get more power/torque for your system if you:

1. Add more motors
2. Decrease wheel size
3. Gear down your drive train.

If you "gear-down" you will move slower and have more torque to do the work that needs to be done.

Bulldozers, tractors, winches, and cranes are all examples of using gears to slow down while increasing the torque available

Getting more speed out of your robot

There are times when you don't want a lot of torque, but rather a lot of speed. There are a number of ways to speed up a robot.

1. Add more motors
2. Reduce the weight of the robot
3. Reduce the weight of the drive train (moving parts)
4. Increase the gear ratio of the drive system

Drills, high gears on bicycles and in cars, air plane engines/ propellers all need to spin at high speed.

Gear Ratio

The gear ratio of a system is the comparison of the drive gear (off the motor) to the end gear (attached to the wheel or other machine part).

1:1 Gear Ratio

This is when the first and last gears are the same size and spin at the same RPM

>1 Gear Ratio

This is when the last gear is moving at a higher RPM than the motor's drive gear (making the system go faster)

<1 Gear Ratio

This is when the last gear is moving at a lower RPM than the motor's drive gear (making the system go slower)

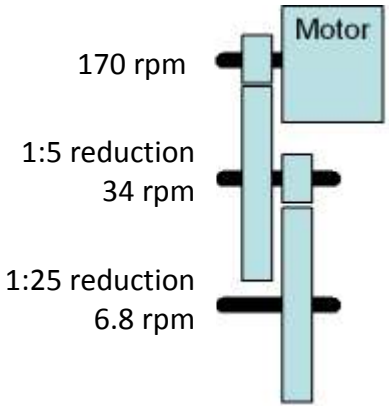
Gear Ratios are given as ratios. A gear ratio of 5:1 means that the last gear will be turning at 5 times the rate of the drive (motor) gear.

A gear ratio of 1:5 means that the last gear will be turning at 1/5th the rate of the drive gear.

Gear ratios can be calculated by comparing the number of teeth on the gears. So going from an 8 tooth gear to a 40 tooth gear gives you an 8:40 ratio (or simplify for a 1:5 ratio).

Making gear trains

A Gear train is a series of gears in a system that allows you to greatly increase or decrease the gear ratio and speed of the machine.



In this example we have one motor, two 8 tooth gears and two 40 tooth gears, plus the axles. The motor drive gear must turn 5 times before the 40 tooth gear turns once. For each time that 40 tooth gear turns the smaller 8 tooth gear on the same axle turns once (same axle right?). But that second small 8 tooth gear must turn 5 times before the 2nd larger 40 tooth gear turns once. The first gear reduction is 1:5 and the second is 1:5. We multiply them together and we get a total gear reduction of 1:25. The motor must turn around 25 times before the second large gear will turn around once.

Making stronger robot gear systems

Making stronger gear systems (not the gear ratio, just the basic mechanical engineering) requires that all axles and gears be placed in a strong manner.

Here we see each axle for each gear held in place by holes on either side. There is also just enough room for the gear but not enough for the gear to move around (side to side). Plates are used to hold the beams in place.

Remember: You can have speed OR torque, but not both.