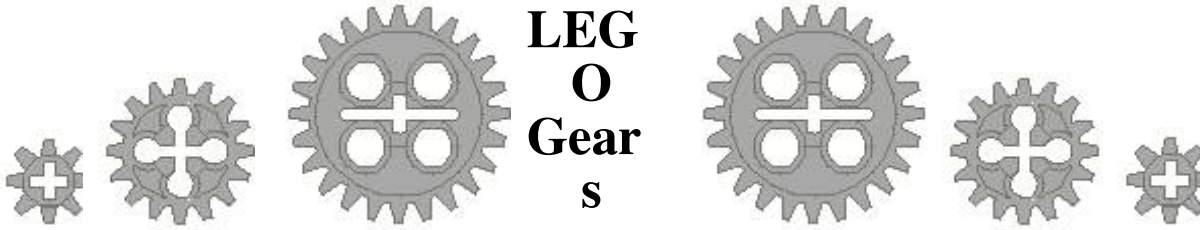
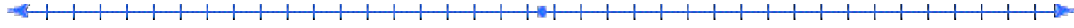


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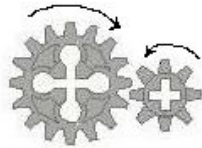
Why use gears in my LEGO robot?

Gears are good when you want to:

- make one motor drive more than one part.
- drive a part that is not attached to the motor shaft.
- move a part slower or faster than the motor speed.
- move a part in a different direction than the motor is going.

How do gears work?

Gears have teeth that touch, or *mesh* with, each other. When one gear turns, it turns all the other gears that it is meshing with. The gear that turns first is sometimes called the “driving” gear. In your robots, the driving gear is probably the one that’s closest to the motor.



8 tooth gear meshing
with 16 tooth gear

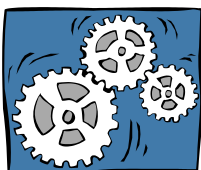
Every time the driving gear moves one tooth, the gears it is meshed with (also called “followers”) move one tooth. The follower always moves in the opposite direction from the driving gear. If the driving gear goes clockwise, the follower moves counter-clockwise.

What is a gear ratio?

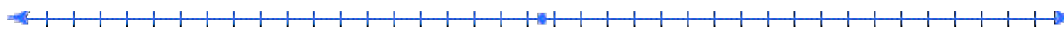
Gears have different numbers of teeth. The *gear ratio* tells about the number of teeth on each gear. Regular LEGO gears have either 8, 16, 24, or 40 teeth. If a gear with 8 teeth meshes with a gear with 24 teeth, the gear ratio is 1:3.

Why does the gear ratio matter?

The gear ratio affects the speed of the two gears. Remember, every time the driving gear moves one tooth, its followers move one tooth.



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| If the driving gear has: | And its follower has: | The gear ratio is: | If the driver turns: | Then the follower turns: |
|--------------------------|-----------------------|--------------------|----------------------|-------------------------------|
| 8 teeth | 8 teeth | 1:1 | once clockwise | once counter-clockwise |
| 8 teeth | 16 teeth | 1:2 | twice clockwise | once counter-clockwise |
| 8 teeth | 40 teeth | 1:5 | five times clockwise | once counter-clockwise |
| 24 teeth | 8 teeth | 3:1 | once clockwise | three times counter-clockwise |

The gear ratio also affects *torque*. Torque is the amount of rotational force, or push, you have. The faster your gear turns, the lower the torque. The slower your gear turns, the higher the torque.

What is gearing up?

Gearing up is when the follower turns faster than the driving gear. (This is the same as saying that the driving gear has more teeth than the follower.) Gearing up is useful when you need something to go fast, but don't need a lot of torque.

What is gearing down?

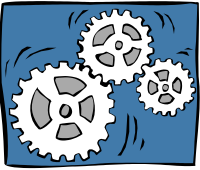
Gearing down is when the follower turns slower than the driving gear. (This is the same as saying that the driving gear has fewer teeth than the follower.) Gearing down is useful when you need a lot of torque, and the speed isn't important.

How do I know when I need more torque?

If your robot isn't moving, you may need more torque. This might happen when you're trying to go uphill or push something heavy. Here's a simple test: Lift your robot in the air and run the program. If the wheels turn in the air, but not when you put your robot on the ground, you need more torque.

I want to know more!

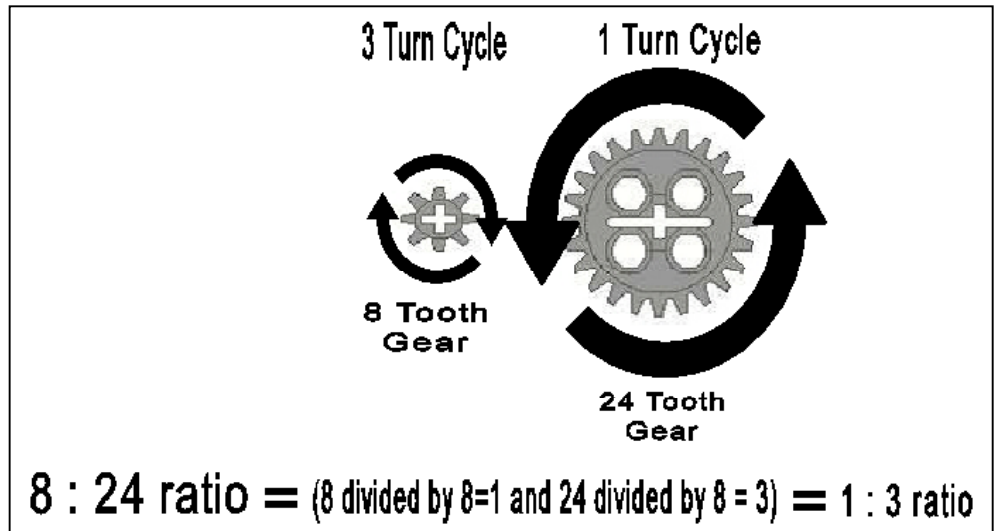
There are several kinds of gears in your kit, and lots of ways to put them together to do different things. Ask your PA or an adult for more help.











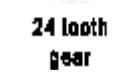



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Another Example:



| | | | |
|-------|---|---|---|
| Motor |  |  | 1:3 Gear Ratio |
| on |  |  | = Slower speed than motor = Gear Down = less speed - stronger push (torque) |
| on |  |  | |
| <hr/> | | | |
| Motor |  |  | 3:1 Gear Ratio |
| on |  |  | = Faster speed than motor = Gear Up = less push-more speed (angular velocity) |
| on |  |  | |