

# *FIRST*® *LEGO*® League *TUTORIALS*

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## GEARING FOR LEGO ROBOTS

SESHAN BROTHERS

# OBJECTIVES

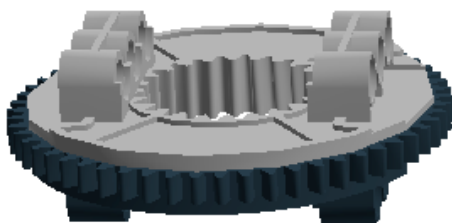
- Learn about the different types of LEGO gears and what you use them for
- Learn how to calculate gear ratios
- Learn some useful gearing techniques

# WHAT IS A GEAR?

- A gear is a wheel with teeth that meshes with another gear
- There are many different kinds of gears
- Gears are used to
  - Change speed
  - Change torque
  - Change direction

# COMMON LEGO GEARS

Turntable



Knob Wheel



Rack Gear



Crown Gear



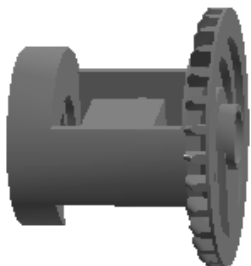
Spur Gears



Double Bevel Gears



Differential



Single Bevel Gears

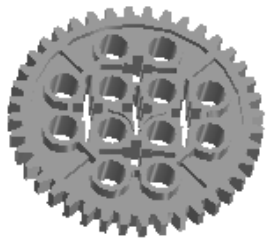


Worm Gear



# NAMING LEGO GEARS

- LEGO gears are referred to by their type and the number of teeth they have



40 tooth spur gear



24 tooth spur gear



16 tooth spur gear



8 tooth spur gear

# DRIVERS, FOLLOWERS & IDLERS

**Driver:** gear that applies force (the gear connected to the motor on a robot)

**Follower:** final gear that is driven

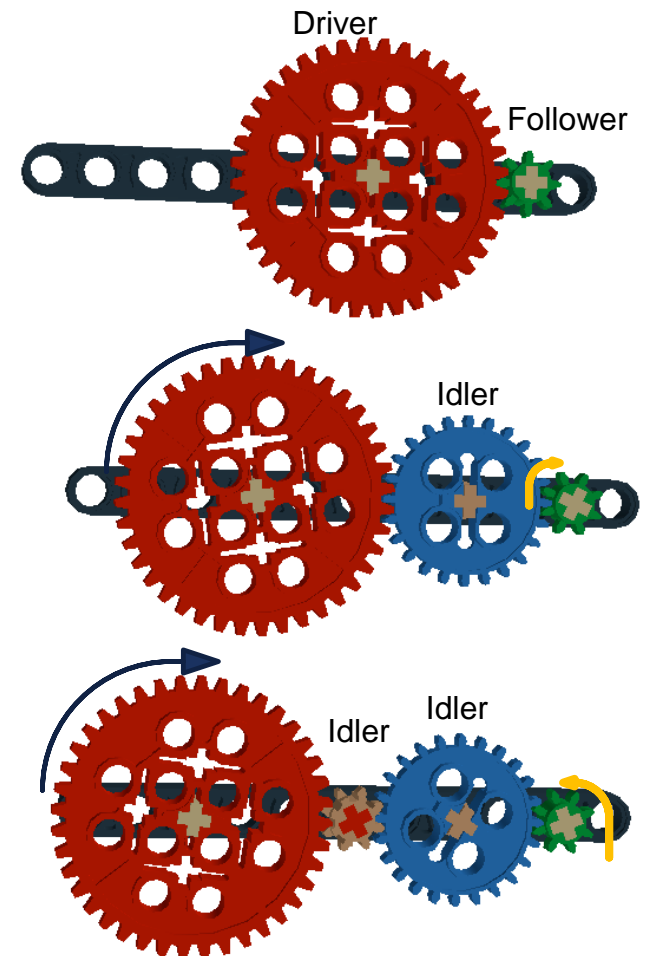
**Idler:** gear turned by driver which then turns the follower

Notes about gears:

1) When 2 gears mesh, the driver makes follower turn in the opposite direction

2) You need an odd number of idler gears to make driver and follower turn in same direction.

3) You need an even number of idlers (or none) to make driver and follower turn in opposite direction



# GEARING DOWN AND UP

## Gearing Down

(increases torque,  
decreases speed)

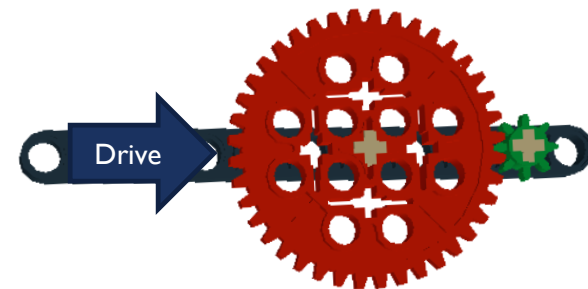
Small Driver Large Follower



## Gearing Up

(increases speed,  
decreases torque)

Large Driver Small Follower

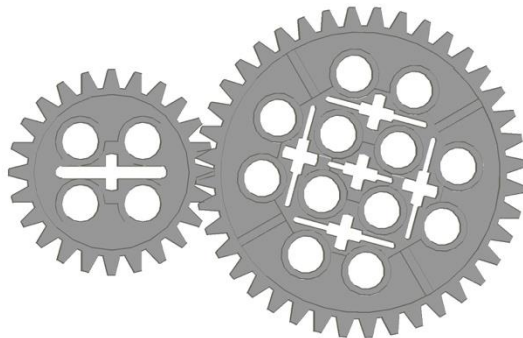


# CALCULATING GEAR RATIOS

- Gear Ratio = number of teeth in follower: number of teeth in driver

Gearing Down  
(increases torque,  
decreases speed)

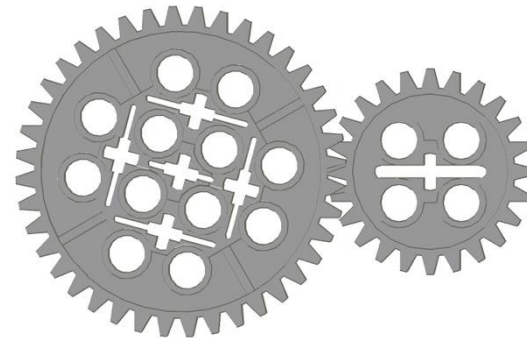
Driver      Follower



$$40/24 = 5:3$$

Gearing Up  
(increases speed,  
decreases torque)

Driver      Follower

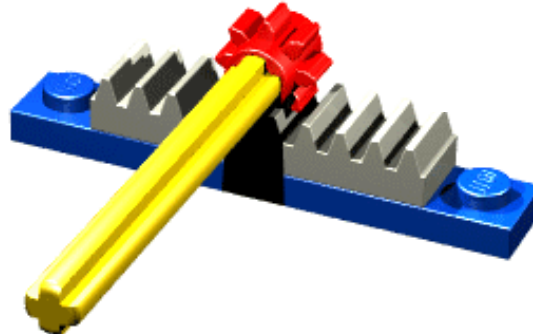
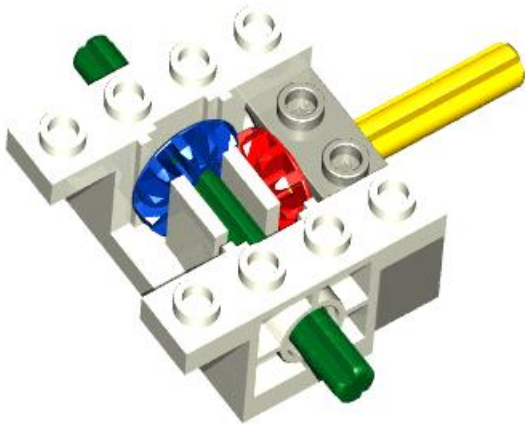


$$24/40 = 3:5$$



# CHANGE THE DIRECTION OF MOTION

You can use gears to change the direction of motion.



Credits: All the animated images are from:  
<http://technicopedia.com/fundamentals.html>. To view them correctly, you will need to use “Slideshow Mode” on PowerPoint.

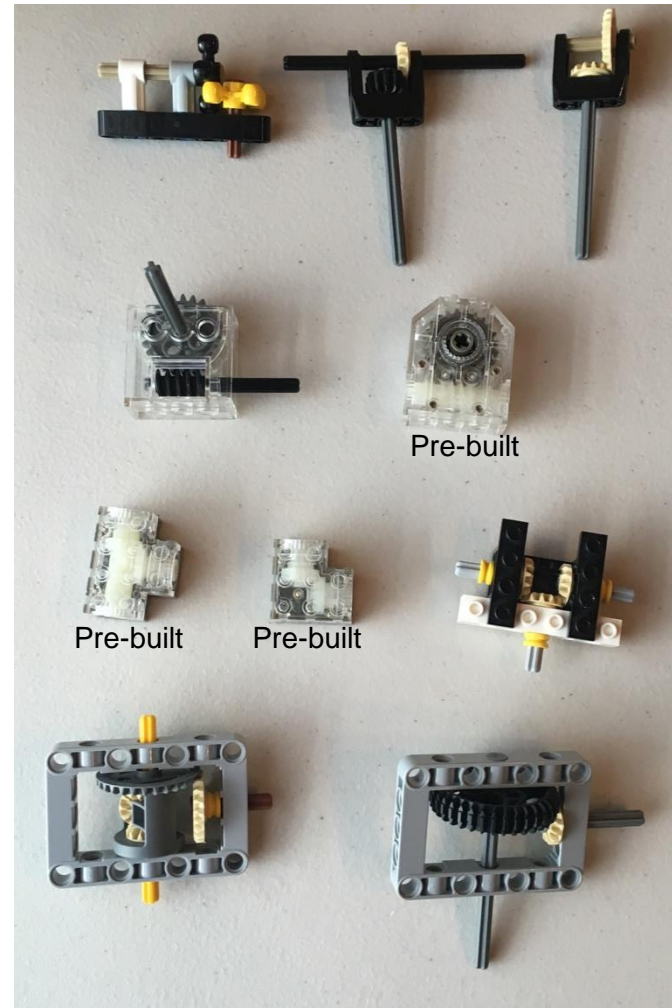
# PROBLEMS WITH LEGO GEARS

- Two common problems that you might face:
  - Gear Slip: Slippage is when the teeth skip on the gears when you apply power
  - Gear Backlash: Backlash is space between the teeth where the gears mesh. When the space is too much, it is called slack/slop. When there is too little, you create too much friction.

Solution: Try to avoid long sequences of gears. Use a gear box. Mesh gears according to specification.

# GEAR BOXES CAN BE HELPFUL

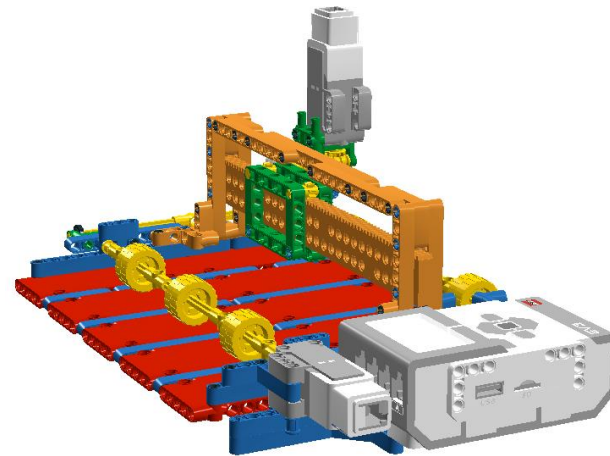
- Gear boxes can help reduce some of the issues you may face when building with gears.
- Some are pre-built (with gears included)
- Some need gears inserted into a gear box
- Some can be assembled from scratch using technic pieces



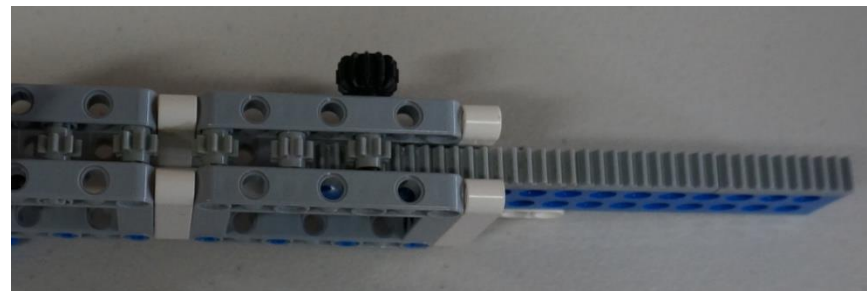
# RACK GEARS FOR VERTICAL & HORIZONTAL MOVEMENT



Support structure of Wall-E7 by Marc-Andre Bazergui is made with rack gears



PIX3L PLOTT3R by Sanjay and Arvind Seshan uses rack gears



# USEFUL ONLINE GEAR TOOL

Tools:

## LEGO™ Gear Ratio Calculator

### CALCULATOR

Click the images to select the respective gears. Start with the first pair and add more pairs as needed:

DRIVER GEAR

FOLLOWER GEAR

+

ADD ANOTHER PAIR OF GEARS

### RATIO CALCULATOR FOR PLANETARY GEARS



Assuming that the red gear is the input, the gray beam is the output and that the yellow gear is not rotating (e.g. fixed to a motor): specify numbers of teeth for red and yellow gear below, then click calculate.

Red gear:  teeth | Yellow gear:  teeth

<http://gears.sariel.pl/>

## OTHER USEFUL RESOURCES

- More about gears:  
<http://sariel.pl/2009/09/gears-tutorial/>
- Gear animations:  
<http://technicopedia.com/fundamentals.html>
- Technic Gearing: Books by Yoshihito Isogawa

# CREDITS

- This tutorial was created by Sanjay Seshan and Arvind Seshan
- More lessons at [www.ev3lessons.com](http://www.ev3lessons.com) and [www.flltutorials.com](http://www.flltutorials.com)



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