Chassis Design

An Overview

What can be used to build your robot?

- Read the Robot Game Rules! (Page 19)
- Everything you compete with must be made of LEGO® elements in original factory condition, except LEGO® string and tubing, which you may cut to length.
- Exception: You can reference a paper list to keep track of programs and a bin to carry your robot.
- There are no restrictions on the quantities or sources of non-electric LEGO® elements, except that factory-made wind-up/pull-back "motors" are not allowed. Pneumatic elements are allowed.


2015 *FIRST*® LEGO® League (FLL®) Challenge

Trash Trek

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FLL

What can be used to build your robot?

- On the robot, marker may be used for owner identification in hidden areas only.
- Paint, tape, glue, oil, dry lubrication, etc. are not allowed.
- Stickers are not allowed except LEGO® stickers applied per LEGO® instructions.


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FLL

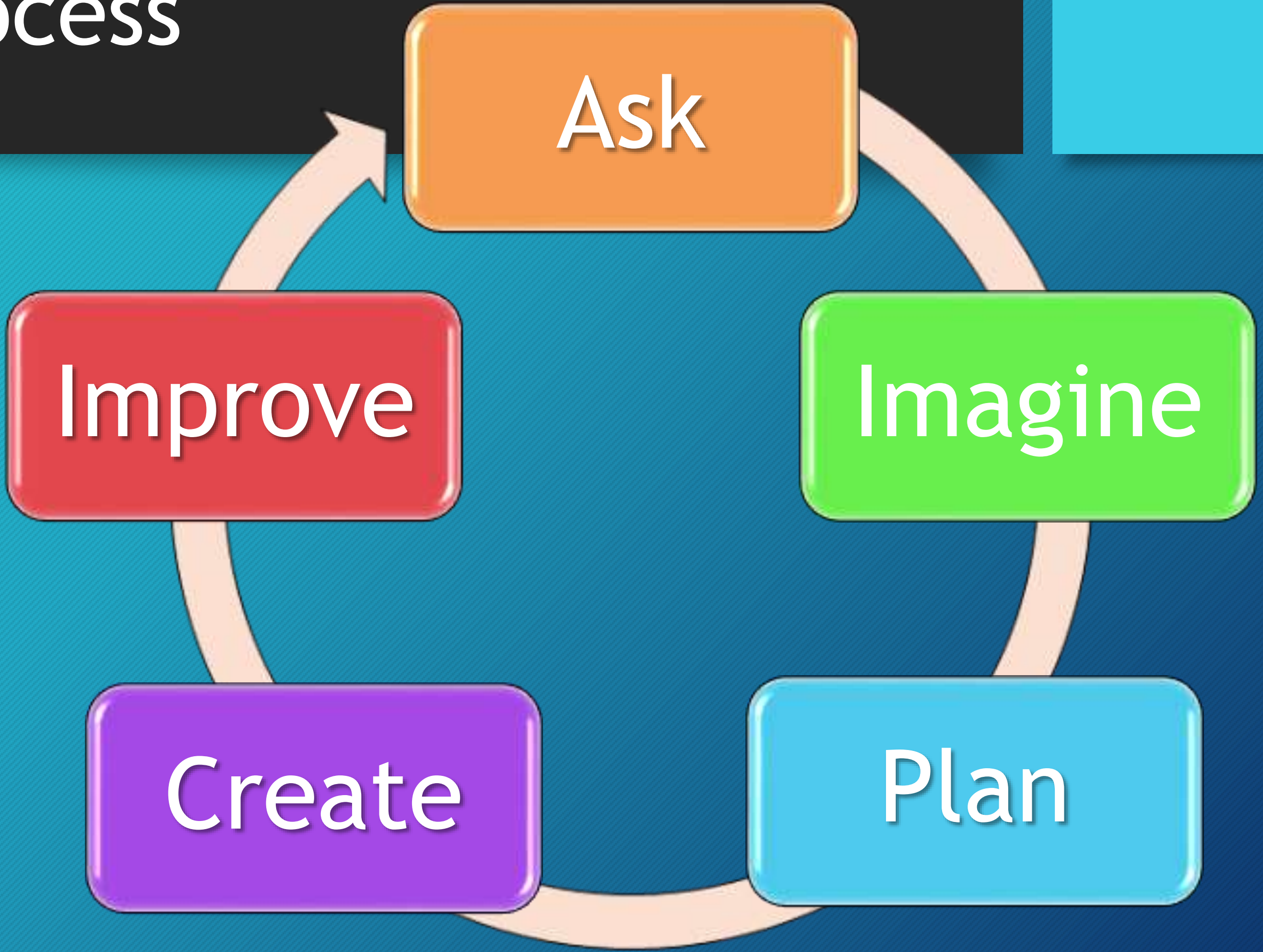
What can be used to build your robot?

- The electric elements used must be the LEGO® MINDSTORMS® type, and the total number of electric elements you may use in one match is limited as follows:
- One Controller (RCX, NXT, or EV3)
- Four Motors - Must be MINDSTORMS® motors
- A fifth motor is not permitted in the competition area (you may have unlimited spare motors at the pit area)
- Unlimited Sensors
  - Must be Touch, Light, Color, Rotation, Ultrasonic, or Gyro sensor
  - Must be LEGO® manufactured MINDSTORM® sensors

Engineering Design Process

Ask

- What is my design supposed to do?
- How will I test my design?
- How will I know it is doing what I want?
- What could keep me from making it do that?



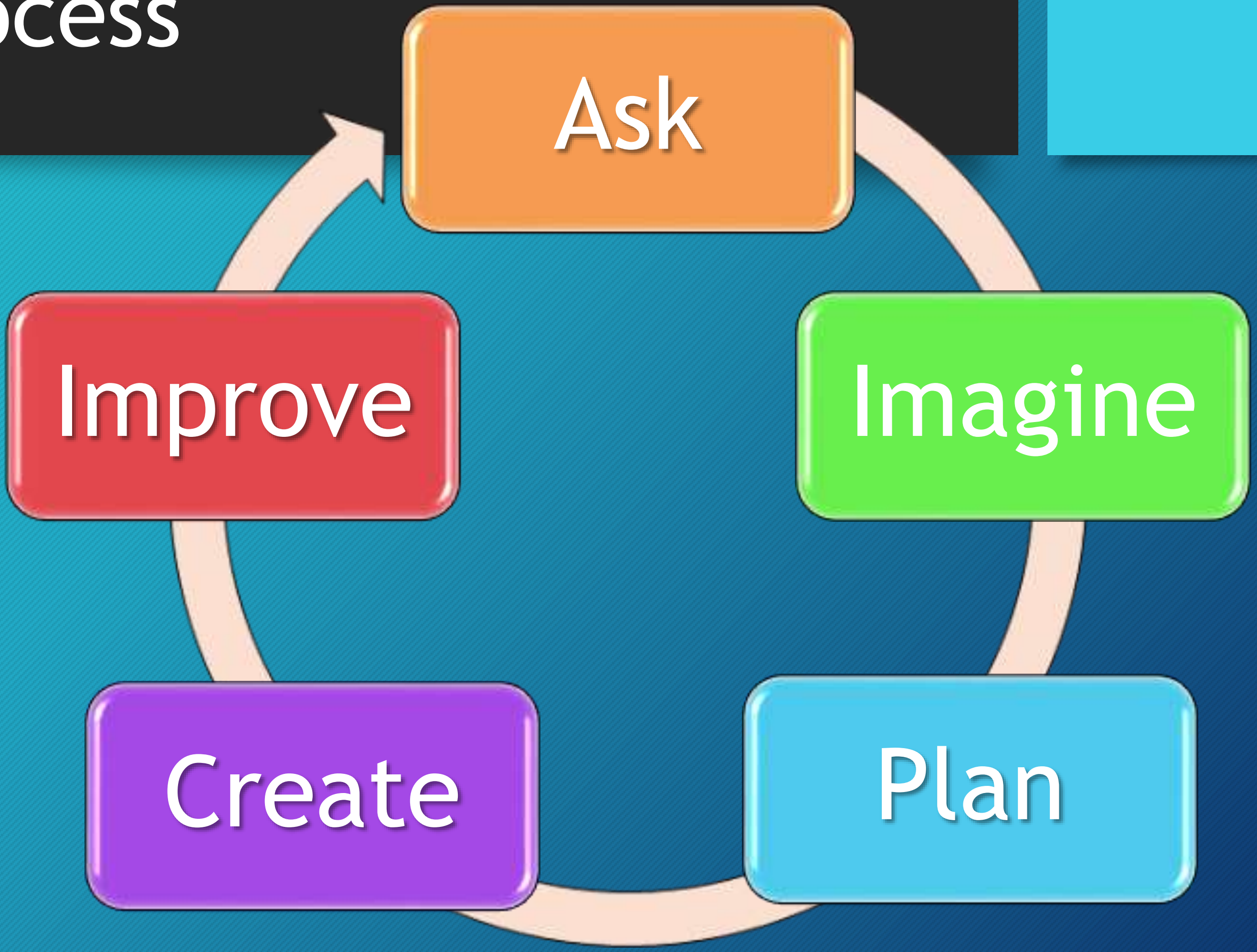
Engineering Design Process

Imagine

- Apply knowledge and creativity to brainstorm ideas.
- Select one to try.

Plan

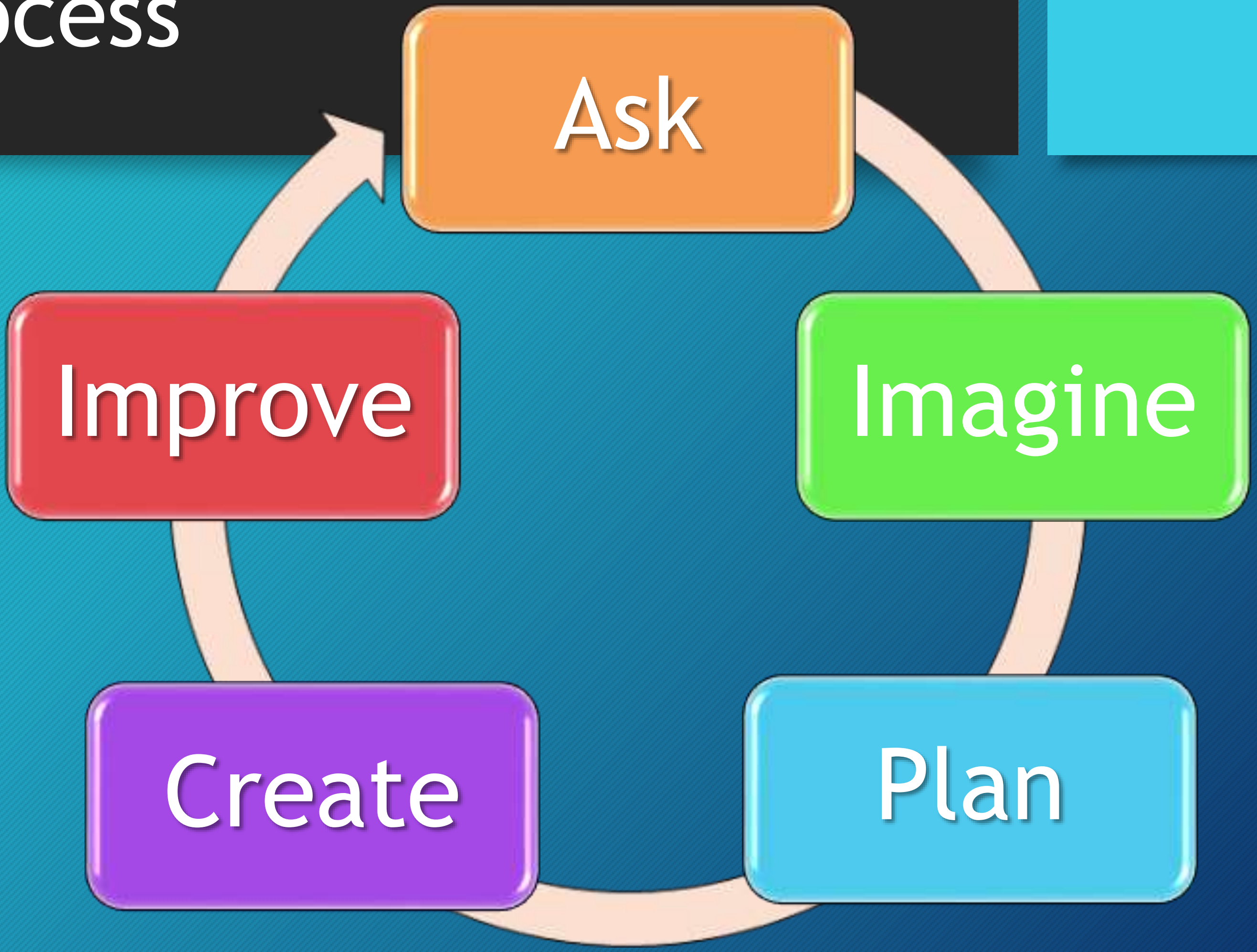
- Plan idea with sketches, diagrams, drawings and notes.
- Plan materials and resources.



Engineering Design Process

Create

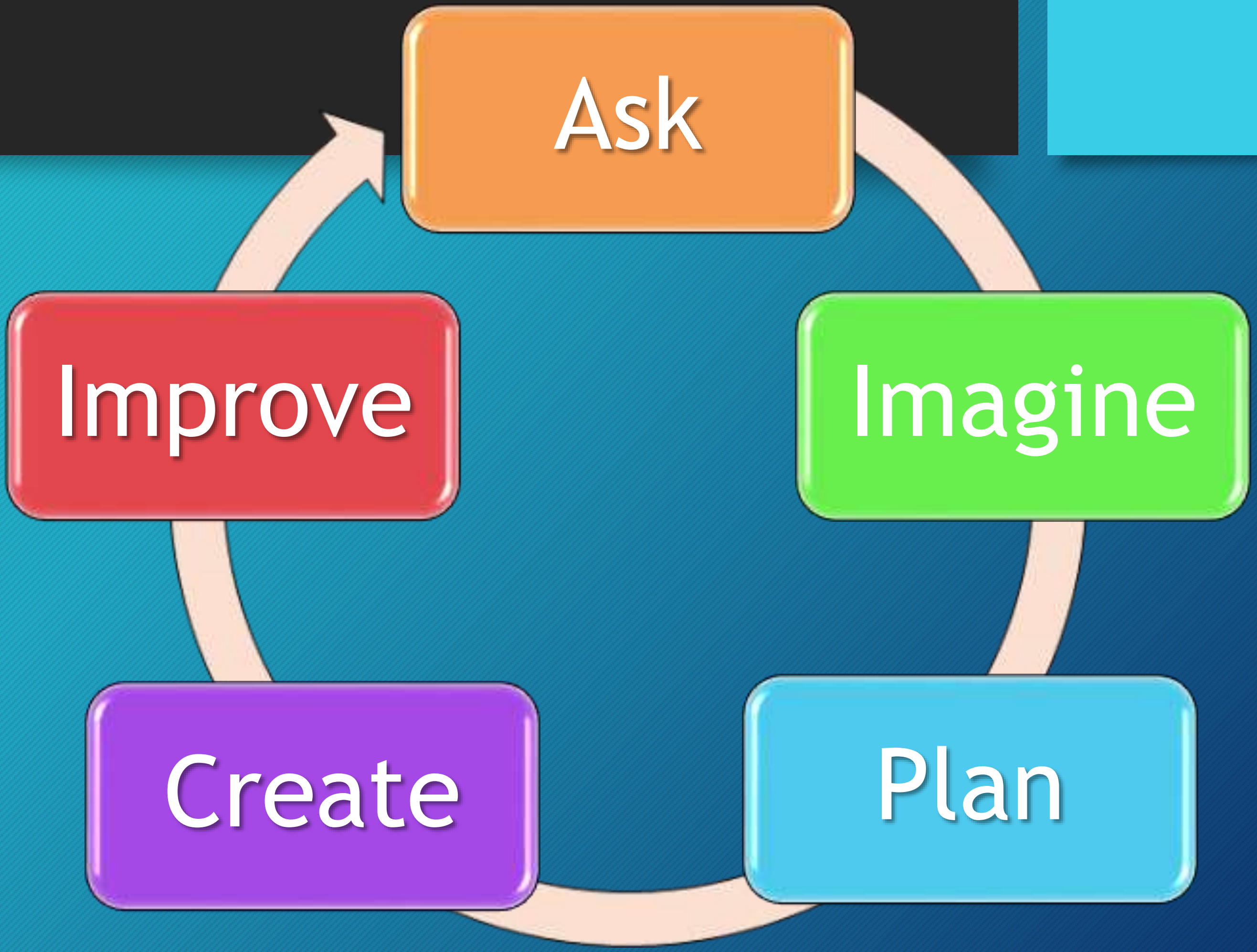
- Create a prototype.
- Test the prototype and record the results.



Design Process

Improve

- Analyze design and test results.
- What change would make the biggest impact on meeting the goal?
- Apply knowledge and creativity to brainstorm ideas.



Common Attributes of *FLL*® Robots

- Two motors are used for the drive wheels, one on each side for turning
- The third and fourth motors for attachments such as a vertical lift, arm mechanism, or attachments
- Multiple attachments for different missions
- Robots must fit inside the base, including 12” height requirement

Attachments are removable - Mechanisms are not

FLL® Robot Design Rubrics

FLL® Robot Design Rubrics

Mechanical Design		Beginning	Developing	Accomplished	Exemplary
	Durability	Evidence of structural integrity; ability to withstand rigors of competition			
	ND	quite fragile; breaks a lot	frequent or significant faults/repairs	rare faults/repairs	sound construction; no repairs
	Mechanical Efficiency	Economic use of parts and time; easy to repair and modify			
	ND	excessive parts or time to repair/modify	inefficient parts or time to repair/modify	appropriate use of parts and time to repair/modify	streamlined use of parts and time to repair/modify
	Mechanization	Ability of robot mechanisms to move or act with appropriate speed, strength and accuracy for intended tasks (propulsion and execution)			
	ND	imbalance of speed, strength and accuracy on most tasks	imbalance of speed, strength and accuracy on some tasks	appropriate balance of speed, strength and accuracy on most tasks	appropriate balance of speed, strength and accuracy on every task

http://www.firstlegoleague.org/event/judging

Chassis Durability

Evidence of structural integrity; ability to withstand rigors of competition

Accomplished: Rare faults/Repairs

Exemplary: Sound Construction; No Repairs

- Things to ask about your robot:
- Does my robot stay together during routine handling?
- Does my robot have excessive flex when moving?
- Does my robot wheels remain in contact with the mat?

Chassis Mechanical Efficiency

Economic use of parts and time; easy to repair and modify
Accomplished: Appropriate use of parts and time to modify/repair
Exemplary: Streamlined Use of Parts and time to repair/modify

- Can the batteries be change/charged easily?
- Can I see the display screen and push the buttons?
- Can I plug/unplug wires easily?
- Are the wires in the way?
- Can attachments be changed easily?
- How long does it take to set up my robot in base?

Chassis Mechanical Efficiency

- Robot Setup – Know Where to Start!
- The base square is big, where does the robot go?
- When positioning the robot, the angle the robot is heading is very important. If the heading is off by 1 degree, four feet from the start, the robot will be off course by over 1 ½ inches
- Even robots that self correct position need to have a consistent starting point
- Proper starting position includes powered arms and attachments
- Alignment tools (jigs) help if built properly

Chassis Mechanization

Ability of robot mechanisms to move or act with appropriate speed, strength and accuracy for intended tasks (propulsion and execution)

Accomplished: Appropriate balance of speed, strength, and accuracy on most tasks.

Exemplary: Appropriate Balance of Speed and Strength on Every Task

Chassis Mechanization

- Does the robot have the right wheels?
  - Big wheels are faster, can move over obstacles, but can be less accurate.
  - Wider tires have more friction than skinny tires making turning less repeatable
- Where is the Center of Gravity (CG) of the robot?
  - Is the robot top heavy?
  - How will the robot’s CG change when it picks up loads?
  - Do the robot avoid tipping on slopes, sharp turns, stops, or in collisions
- What happens when the robot backs up?

Chassis Basics

Chassis styles

- 2 wheels and skid(s) - usually fine if no ramps to climb
- 2 wheels and caster wheel (3-point design) - caster wheel can change robot course (supermarket carts)
- 2 wheels and ball (3-point design)
- 4 wheels (4-point design) - often one pair is without tires to slide while pivoting
- 6 wheels - Larger than most FLL robots, smaller base this season
- Treads - stable, can be hard to predict turns
- Exotics – walking, time consuming to build, inconsistent movement

Chassis mobility

- Size of chassis – it has to navigate around the obstacles on robot field
- A bigger chassis require more motor power draining batteries quicker
- Remember, after the robot is built, you still need to get to the battery compartment or charging plug on the brick
- Chassis will need places for attachments to attach
- Wires from brick to motors/sensors should be tucked away so they don’t catch on anything

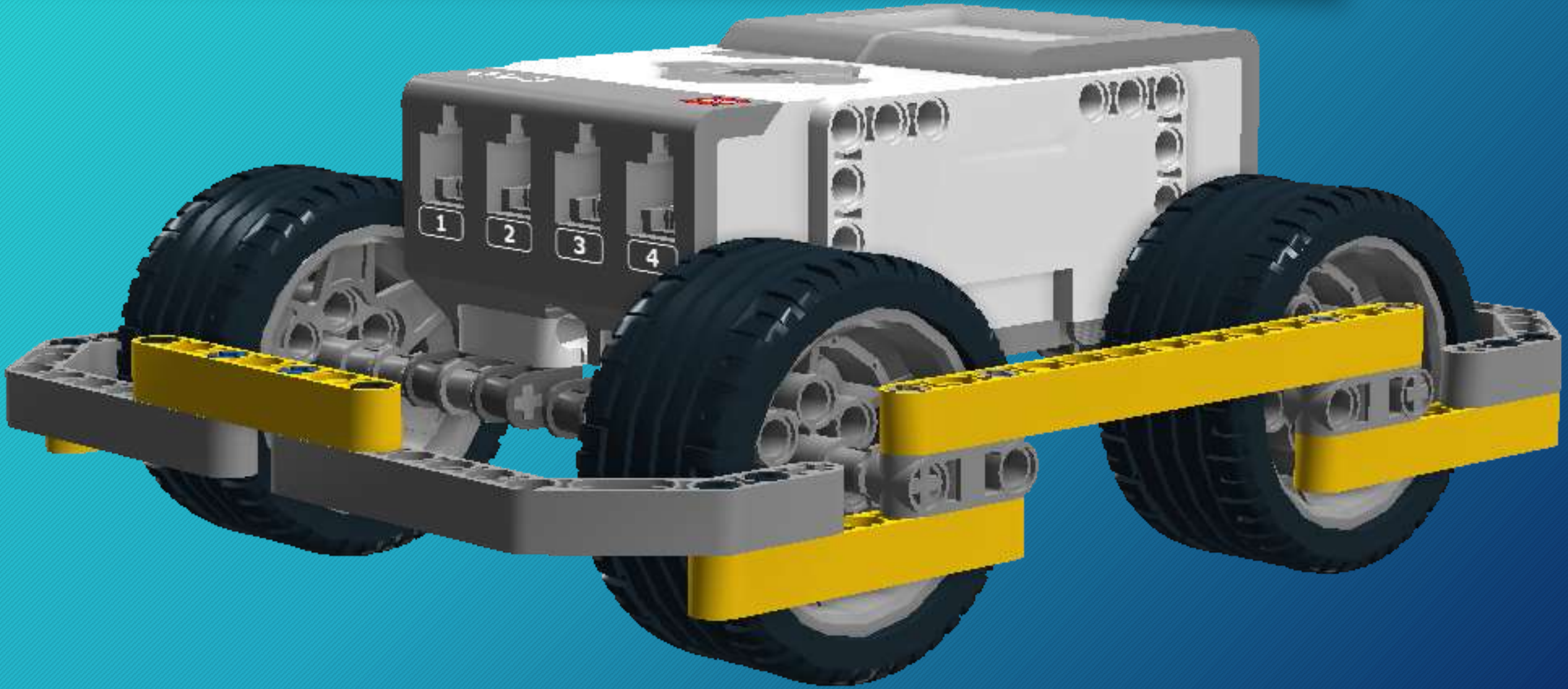
Chassis mobility

- Will gears help?
- Little Gear on motor and big gear on attachment or wheel
  - Slower
  - More Precise
  - More Torque
- Big gear on motor and little gear on attachment or wheel
  - Faster
  - Less Precise
  - Less Torque

Wheels, Tracks and Axle tips

- Tracks
  - Low Friction/High Slippage
  - Motion and Turns not repeatable
- Large wheels go further per revolution
  - Friction varies with different wheels
  - Consider how they pivot turn and go straight
- Wheel Axle Support
  - More support, less wiggle/sag
  - Support from both sides is best

Wheel support



Navigation

Building to go straight

- Straight motion
  - Wheel balance
  - Wheel alignment

Robot placement

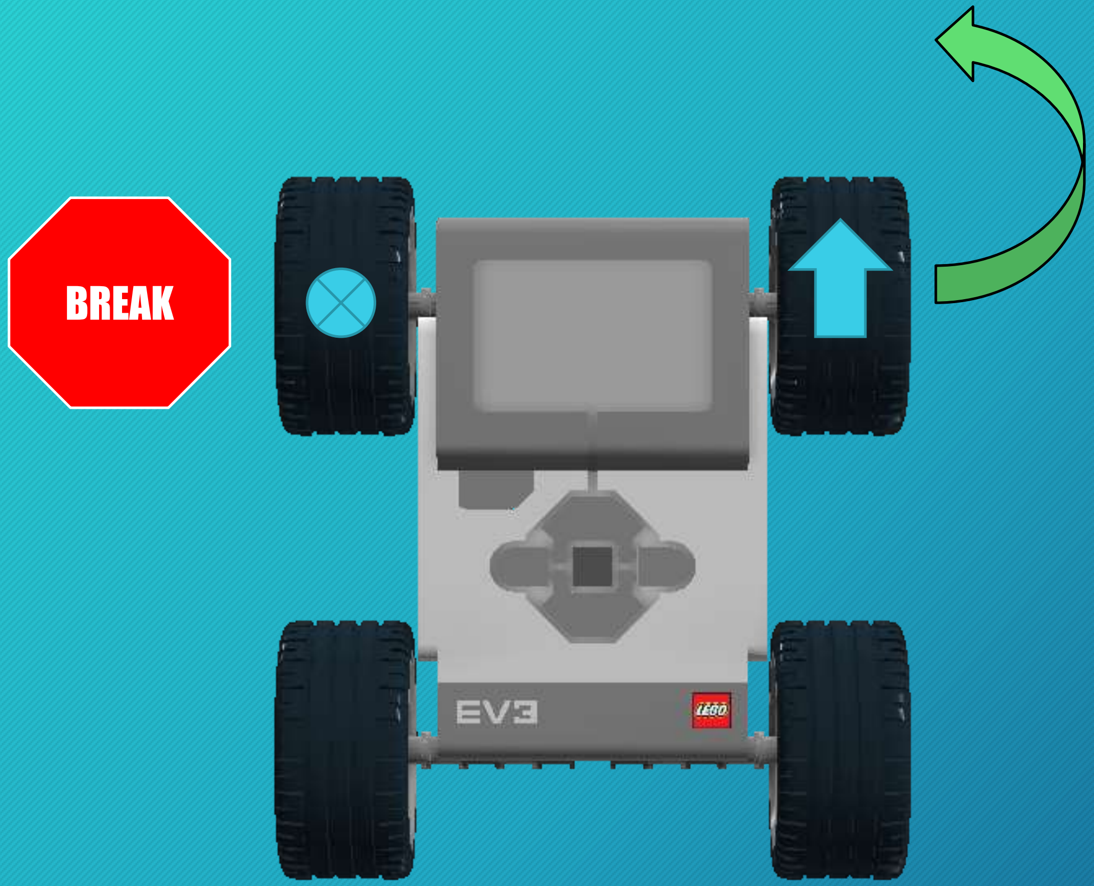
- Jigs / Alignment tools
  - Align with solid edges of robot, not by sight
  - Provide three points of contact to get both the angle and front/back positions correct
  - Jig / Alignment tool can't interfere with robot as it begins to move
  - Table walls may vary. South edge of mat is always against the south wall, but east and west are center, and north falls wherever.

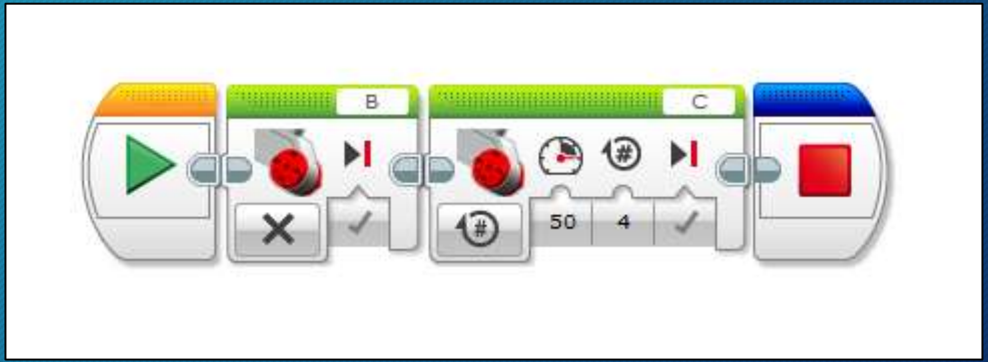
Three types of turns

- The robot will turn when one wheel moves at a different speed from the other
- The greater the difference in wheel speeds, the tighter the turn

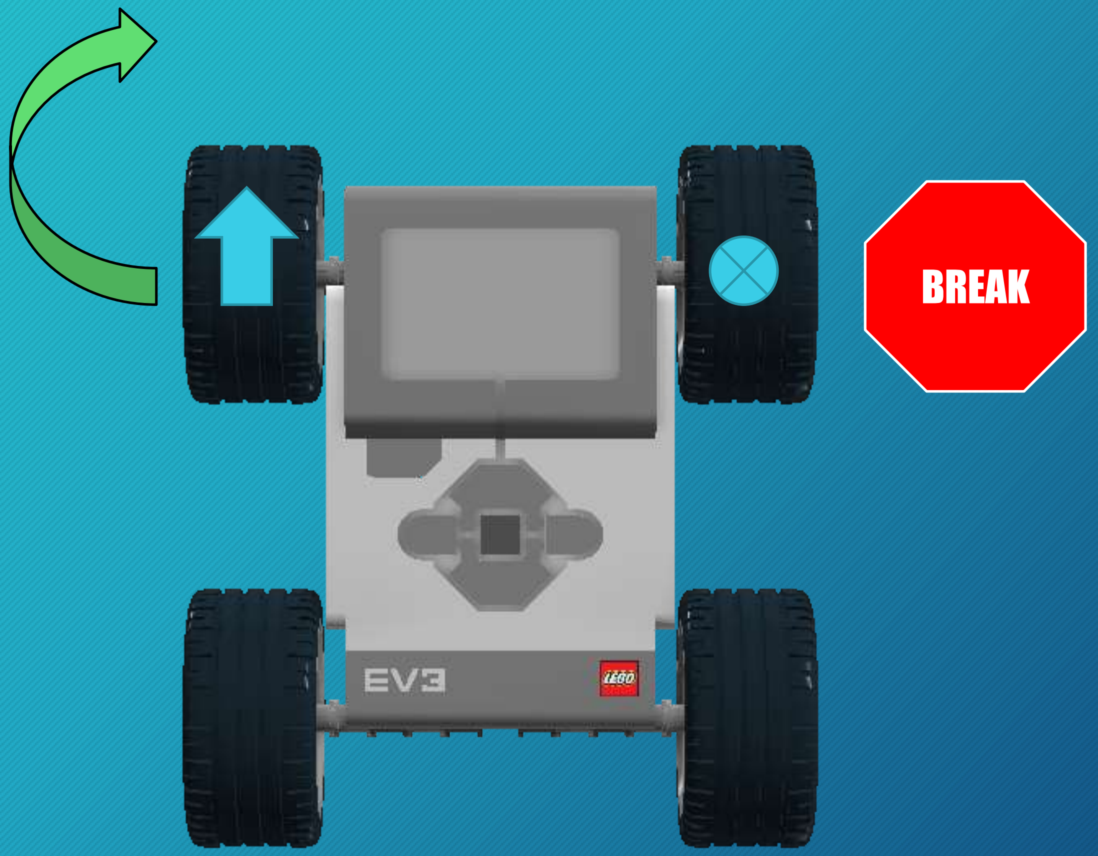
- Pinpoint - robot spins around a point (tank turn)
- Pivot - robot turns about a fixed wheel
- Curved - robot turns about an arc

Pivot turn

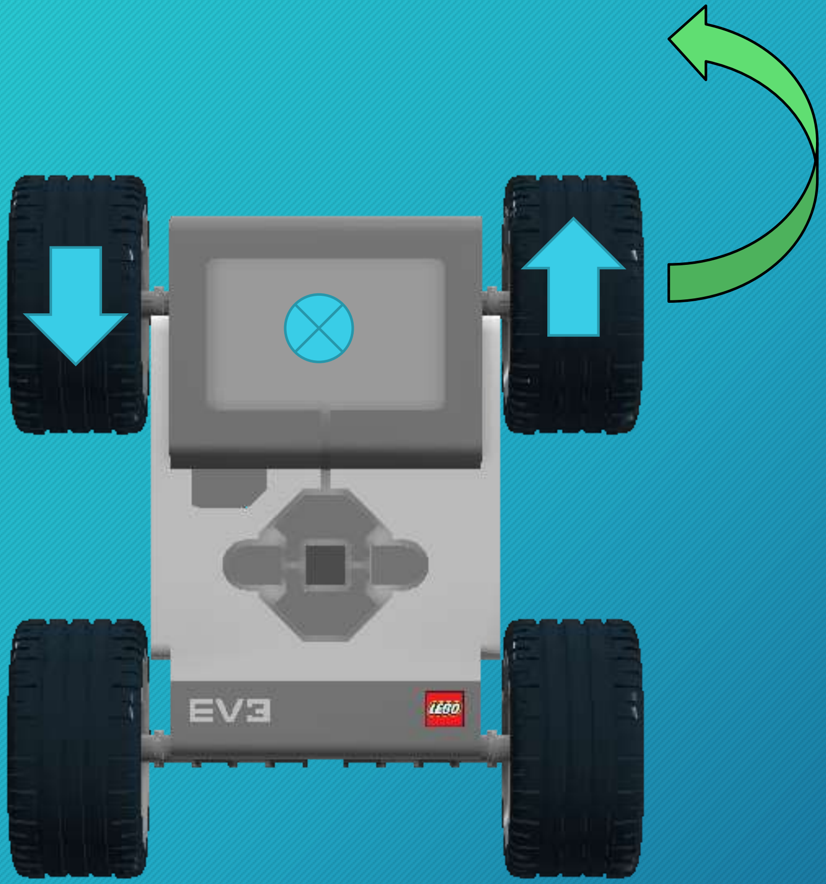


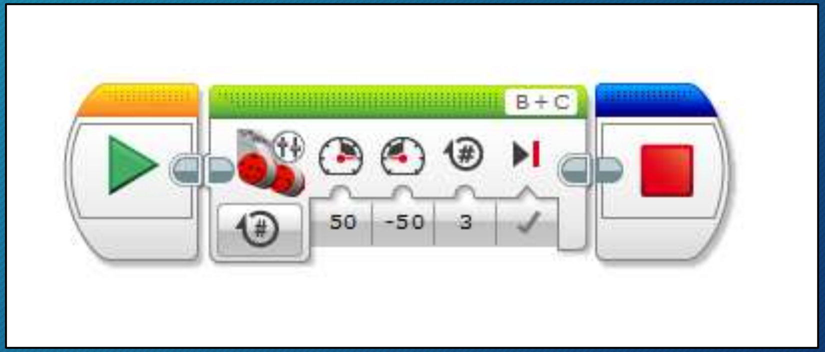


Pivot turn

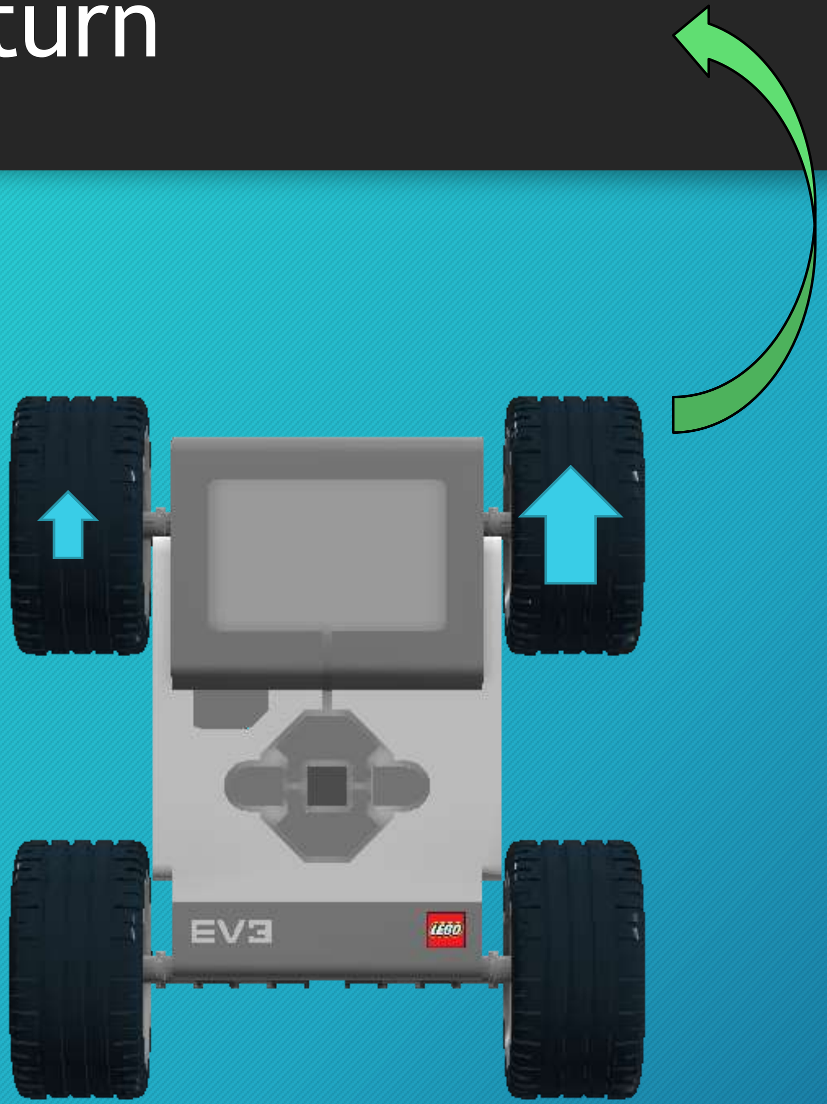


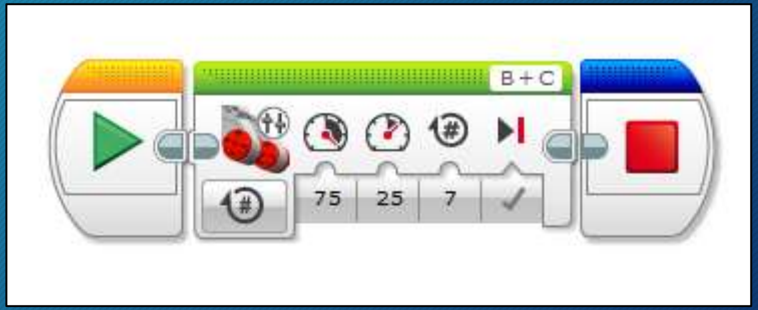
Pinpoint turn





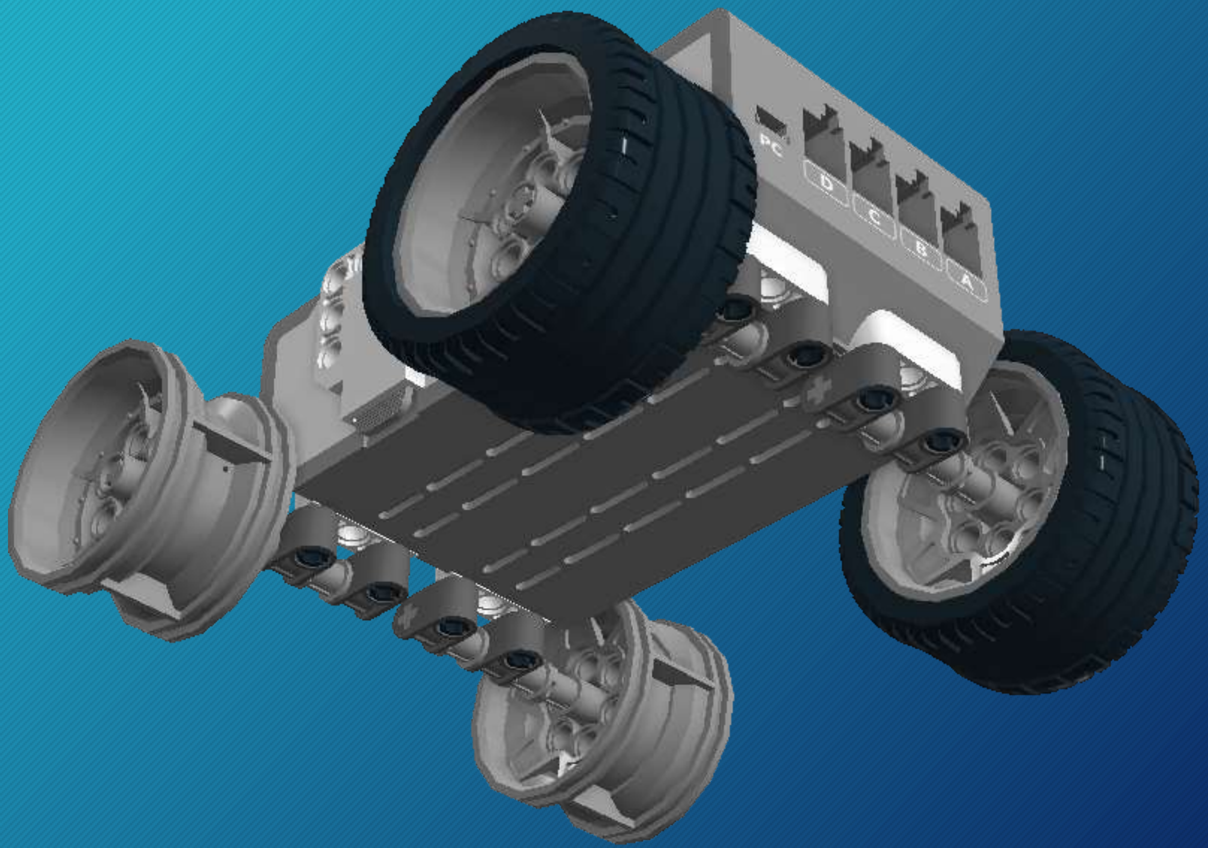
Curved turn





Steering

- Consistent steering
    - Remove tires from rims
    - Reduce friction
    - Brake stationary wheel on pivot turns



Navigation methods

- Wall following
- Horizontal guide wheels, approach wall at shallow angle
- Line following
- Use the light generated by the light sensor itself
- For greatest accuracy, box light sensors to eliminate (as much as possible) ambient light
- Calibration can help to reduce the effect of changes in external lighting, but is hard to eliminate
- Light sensors tend to hunt – pivoting on one wheel (instead of two) tends to be less jittery and make faster progress
- Take advantage of knowing the proper course for the mission – not a general – purpose line follower

Online

- Lego Educational: http://legoeducation.us/
  Go to the "SHOP" menu and then select "LEGO Spare Parts and Accessories"
- BrickLink: http://www.bricklink.com
- Brick Owl: http://www.brickowl.com/
- Gears: http://gears.sariel.pl/
- LEGO® Digital Designer: http://ldd.lego.com/en-us/
  CAD for LEGOs®
- Techbrick: http://www.techbrick.com/
- BrickSet: http://brickset.com/browse