

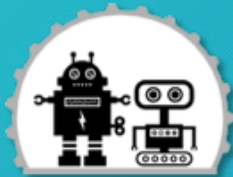
# Chassis & Attachments 101

## Part 1: Chassis Overview

# Introductions

- Rest rooms location.
- Food and Drink.
- Cell phones.

Today presentation available at:



<http://www.roboplex.org/fll>



# Equipment

## FLL EV3 Robot Set

- EV3 Core Set
  - EV3 “brick”
  - EV3 Electronics
  - Technic LEGO components
- EV3 Expansion Set
- EV3 Programming Software and License
- Robot Educator Bot
  - Recommended first build
  - Directions and tutorials in EV3 Software Education version



# 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 use 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.





# What can be used to build your robot?

- LEGO® pneumatic elements are allowed.
- 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.



# 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 MINDSTORMS® sensors



# Rule Changes for 2018

## MAJOR

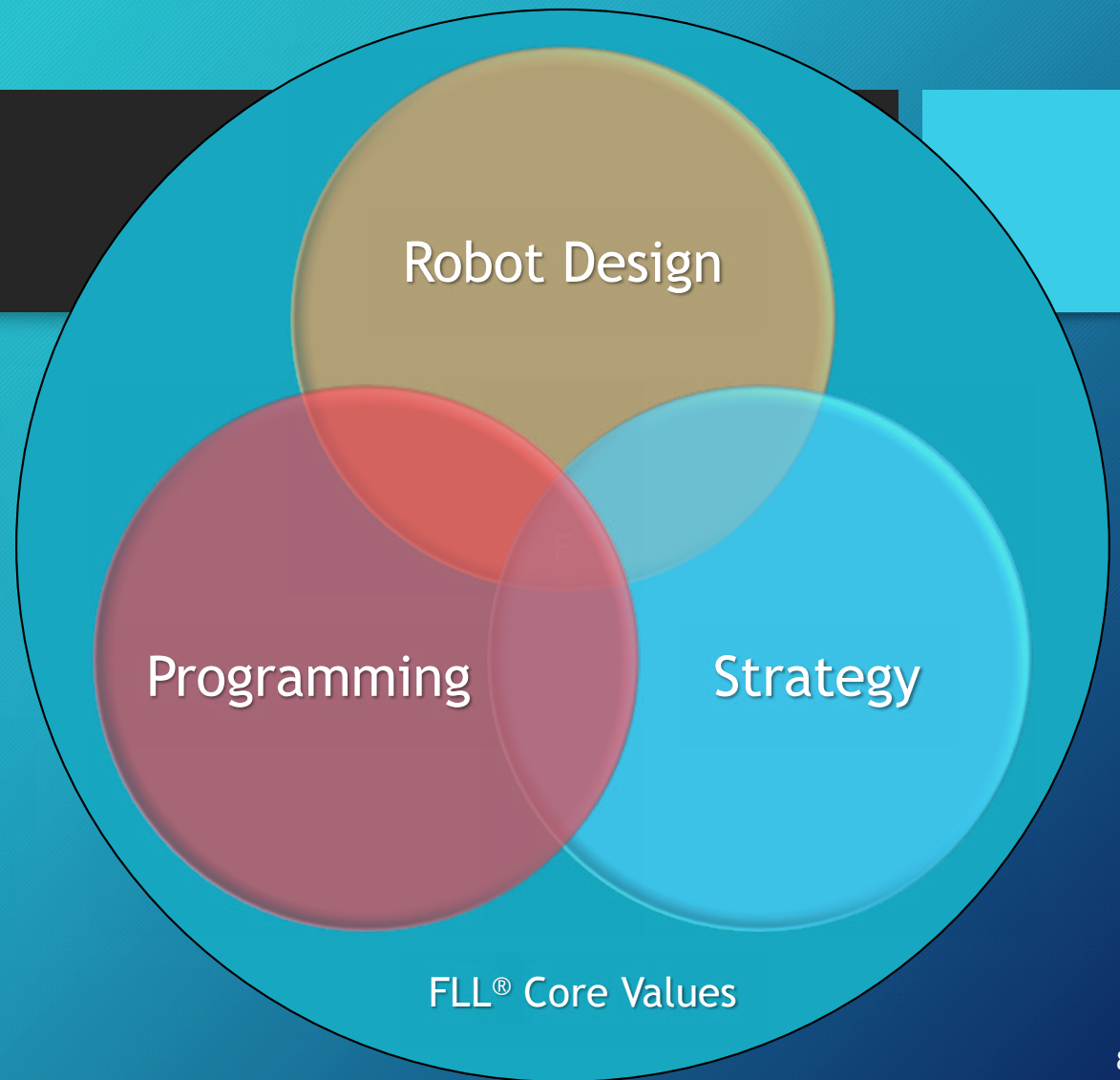
- If you interrupt the Robot while it's transporting something it took from Base during the most recent launch, you can now keep that object.

## MINOR

- Border lines are always part of the area they define.
- Disputes related to the thickness of thin lines (such as the border of Base) always settle in favor of the team.
- You need to conform to local event standards regarding the style and size of your Storage trays and carts.
- It's OK to shut off the Robot and leave it in place without penalty if it's done with intended Missions.

# Achieving Robot Performance

- Teams that are consistently top performers are always balanced in robot design, programming, and strategy.
- Teams will naturally be stronger in one area, but to neglect the other areas will result in inconstant results.





# Strategy



Great robot design + poor strategy = inconsistent scores

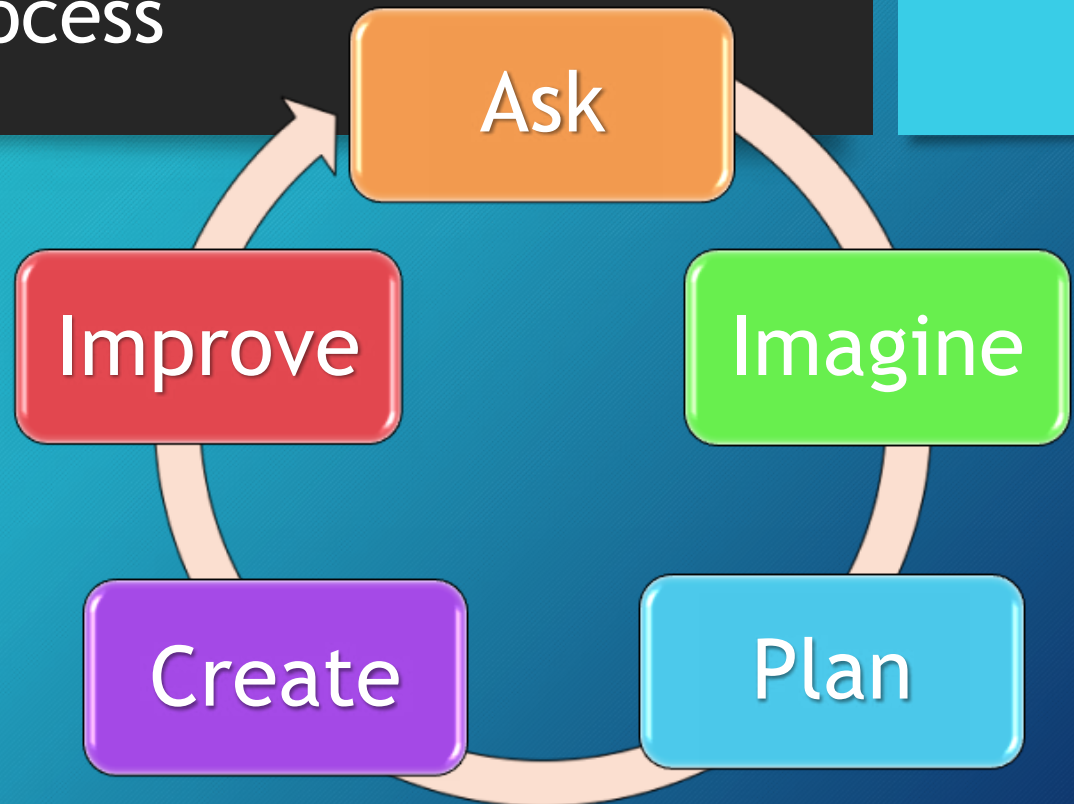


Fair robot design + good strategy = consistent scores

# 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?





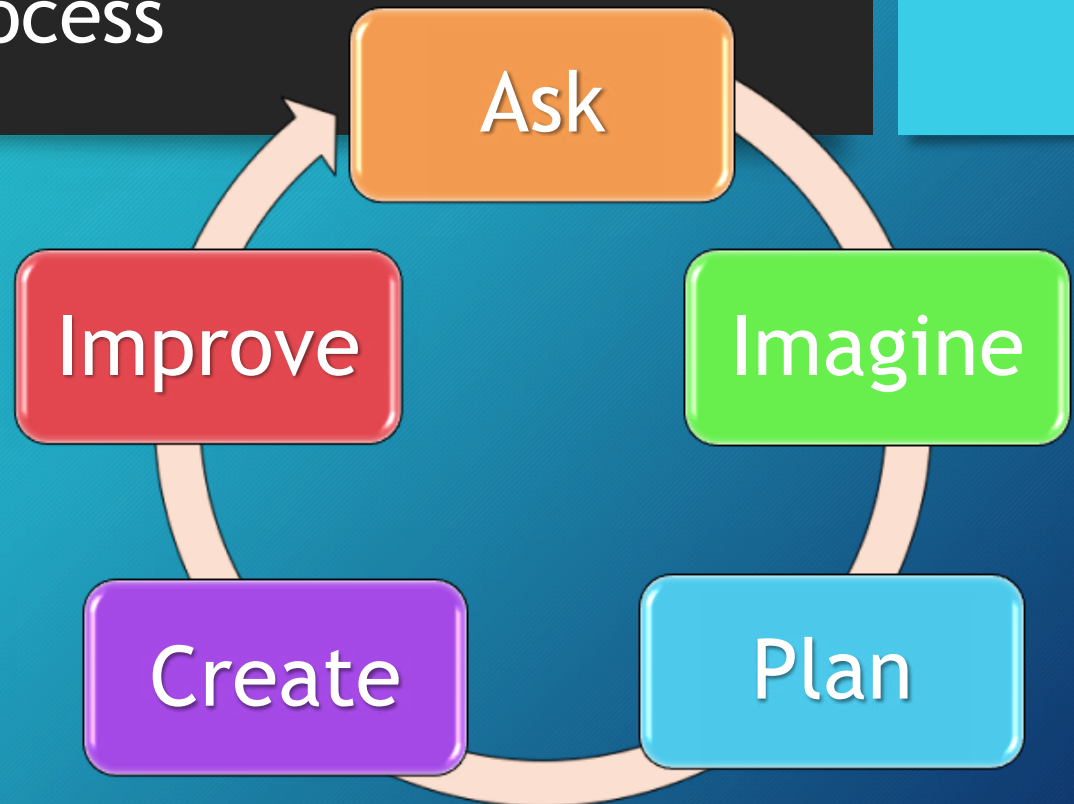
# Engineering Design Process

## Imagine

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

## Plan

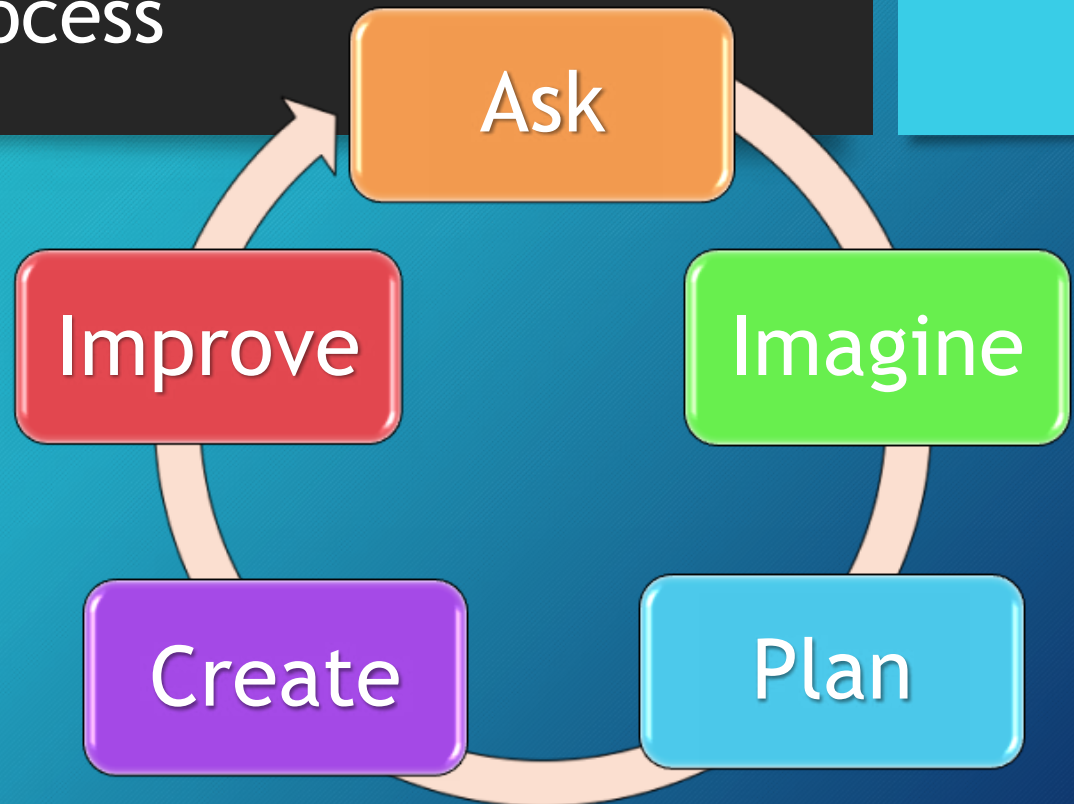
- Plan idea with sketches, diagrams, drawings and notes.
- Plan materials and resources.



# Engineering Design Process

## Create

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

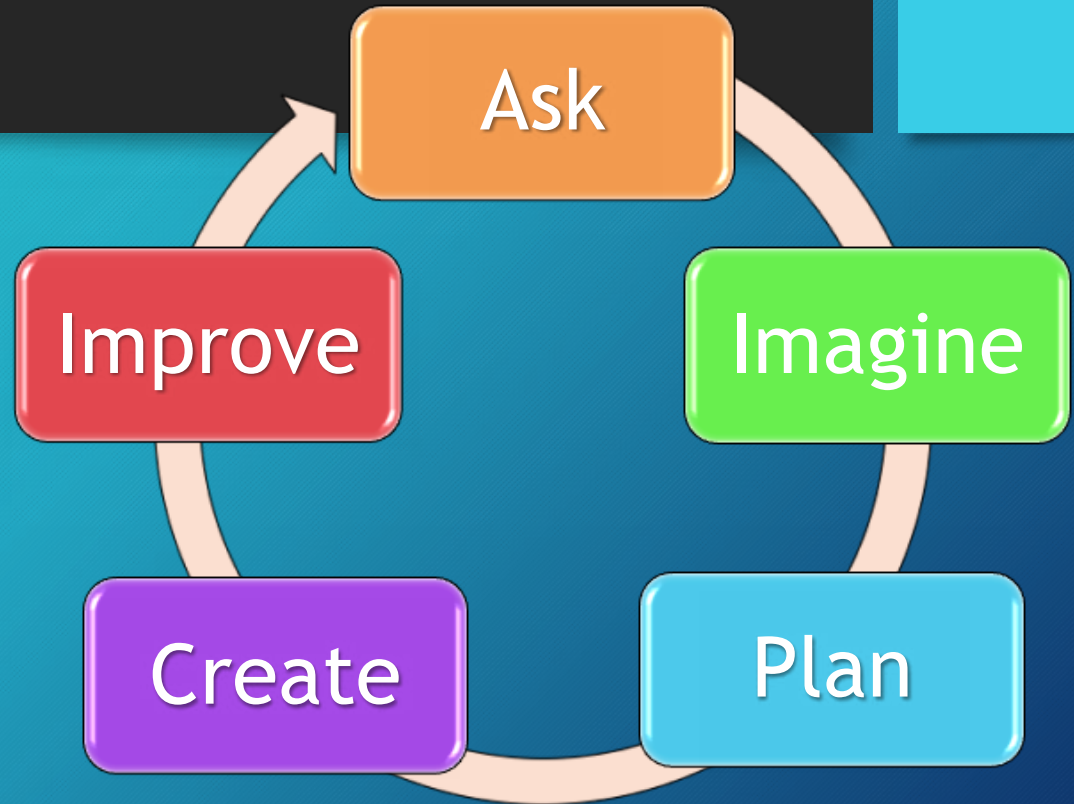




# Design Process

## 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

**Attachments are removable - Mechanisms are not**



# Robot Design Tip

- Coach Mike shared a pretty cool story with us about a simple innovation on his team:
- “Pretty good” design can get in the way of innovation. For our FIRST® LEGO® League team Avian Allies (24879) that was sometimes the case. We didn’t want to take apart or change already working attachments. Until recently when one of our team members had a simple, but inspired idea. He said, “I wish there was an undo button for robot/attachment design.”
- I asked the team how we might create an “undo button.” They suggested taking photos at each stage of deconstruction and development. Now there is nothing earth shattering about the idea of taking photos of the team’s designs. However, branding the process as an UNDO button encourage them to actually do it consistently. It has helped to spawn more innovation and risk taking on our team. They discovered that naming something matters and that sometimes innovation is right in front of you.



# Robot Design Executive Summary and *FLL*® Robot Design Rubric



The Robot Design Executive Summary and Robot Design Rubrics  
are available at <http://www.firstinspires.org>



# Robot Design Executive Summary (RDES)

## Design Details Outline

1. **Fun:** Describe the most fun or interesting part of robot design as well as the most challenging parts. If your robot has a name, who chose the name and why.
2. **Strategy:** Explain your team's strategy and reasoning for choosing and accomplishing missions.
3. **Design Process:** Describe how your team designed your robot and what process you used to make improvements to your design over time.
4. **Mechanical Design:** Explain to the judges your robot's basic structure, how you make sure your robot is durable and how you made it easy to repair or add/remove attachments.
5. **Programming:** Describe how you programmed your robot to ensure consistent results.
6. **Innovation:** Describe any features of your robot design that you feel are special, different or especially clever.

# FLL<sup>®</sup> Robot Design Rubrics

		Beginning	Developing	Accomplished	Exemplary
Mechanical Design	<b>Durability</b>	Evidence of structural integrity; ability to withstand rigors of competition			
	N D	quite fragile; breaks a lot	frequent or significant faults/repairs	rare faults/repairs	sound construction; no repairs
	<b>Mechanical Efficiency</b>	Economic use of parts and time; easy to repair and modify			
	N D	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
	<b>Mechanization</b>	Ability of robot mechanisms to move or act with appropriate speed, strength and accuracy for intended tasks (propulsion and execution)			
	N D	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.firstinspires.org/resource-library/fll/judging-rubrics>



# 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

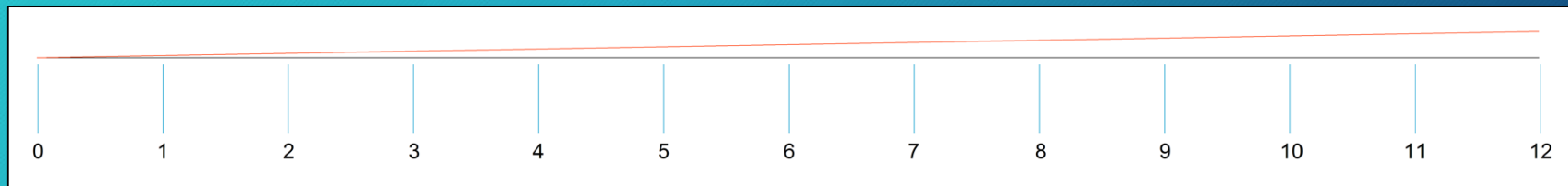
Exemplary: Streamlined Use of Parts and time to repair/modify

- 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 is bigger than it appears, 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 (half the length of the field) from the start, the robot will be off course by over 1 ½ inches



# Chassis Mechanical Efficiency

- Even robots that self correct position need to have a consistent starting point
- Proper starting position includes powered mechanisms and attachments, everything must start within base
- Alignment tools, such as robot bumpers and jigs help if built properly and consistently used



# 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.
- How does the battery charge effect the robot movement?
  - The theoretical output speed of the EV3 large motor is 52.5 RPM at 9V, but at 7V only 39 RPM.



# Chassis Mechanization

- Where is the Center of Gravity (CG) of the robot?
  - Is the robot top heavy?
  - How will the robot's CG change when the robot picks up something?
  - Does the robot tip over 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 caster 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, robot must fit in base.
- Treads - stable, can be hard to predict turns
- Exotics - walking, time consuming to build, inconsistent movement



# Chassis mobility

Size of chassis: the robot has to navigate around the obstacles on robot field





# Chassis mobility

- 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 motor and sensors should be tucked away so they don't catch on anything

# Chassis mobility

Will gears help?

- Small gear on motor and big gear on attachment or wheel
  - Slower, More precise, More torque (power)
- Big gear on motor and small gear on attachment or wheel
  - Faster, Less precise, Less torque

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



# Navigation



# 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



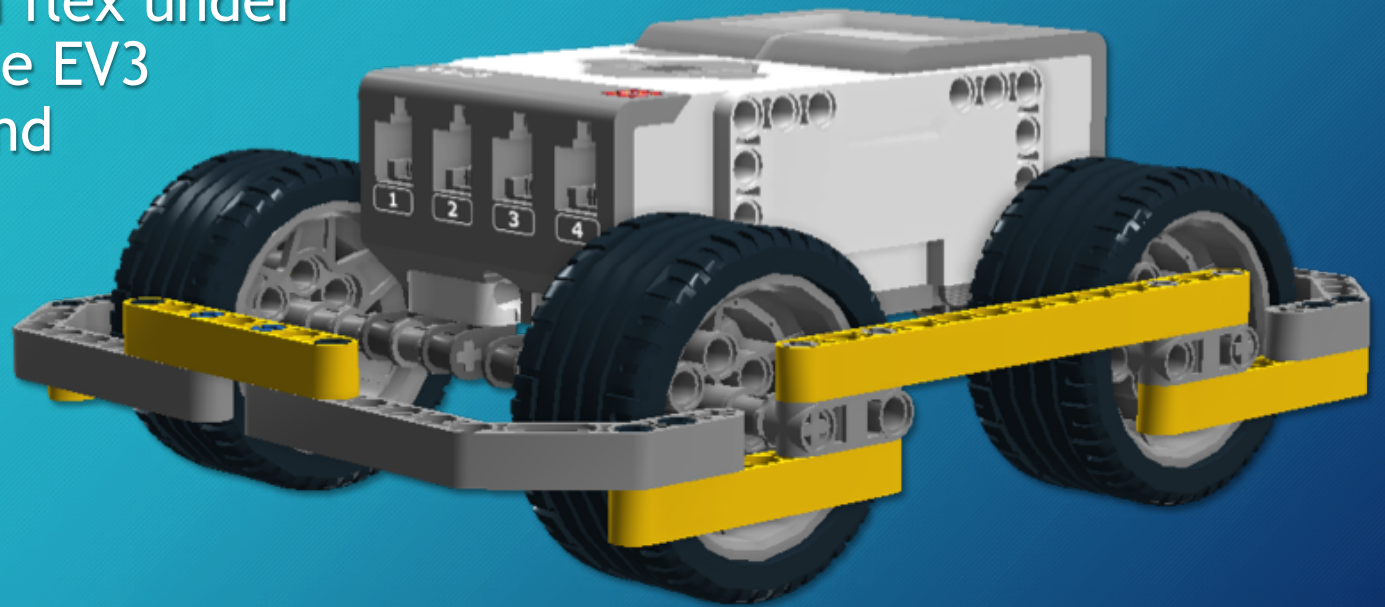
# Building to go straight

- Straight motion
  - Wheel balance
  - Wheel alignment

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

# Wheel alignment and support

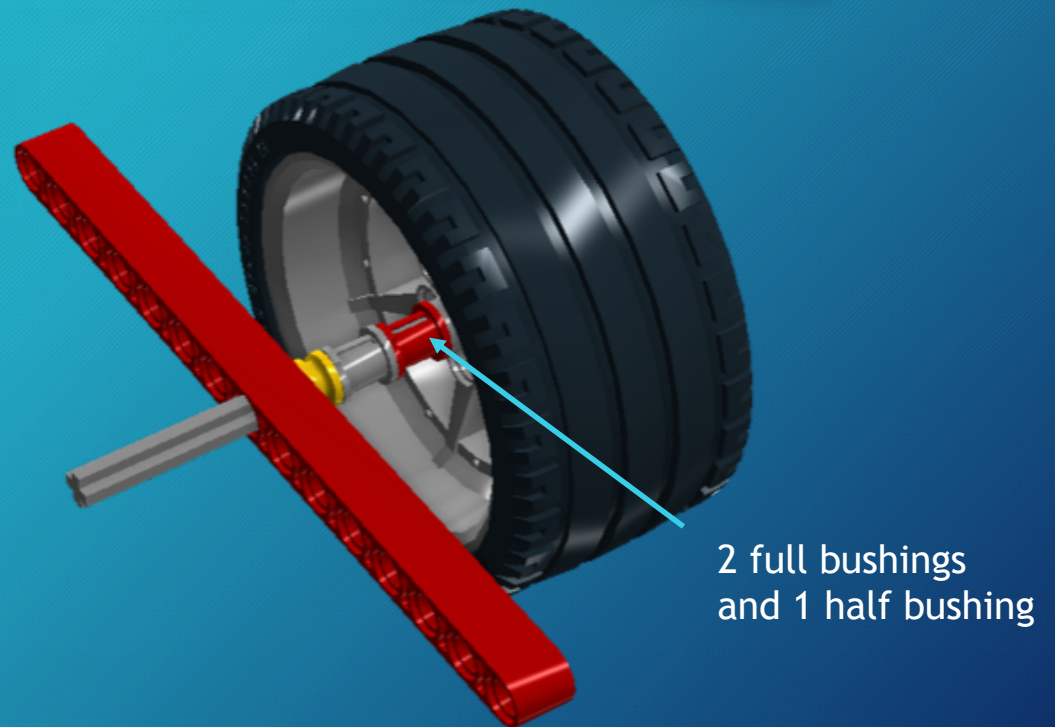
- LEGO® axles can flex under the weight of the EV3 brick, battery and parts.





## Wheel Support - Poor

- Wheels should be mounted close to supporting beam, but not rubbing against it



# Wheel Support - Better





## Wheel Support - Best

- Beams on both sides provides the best support



# Robot placement

- Jigs / Robot bumpers / 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 left



Powering the right wheel while breaking the left will cause the robot to turn right.





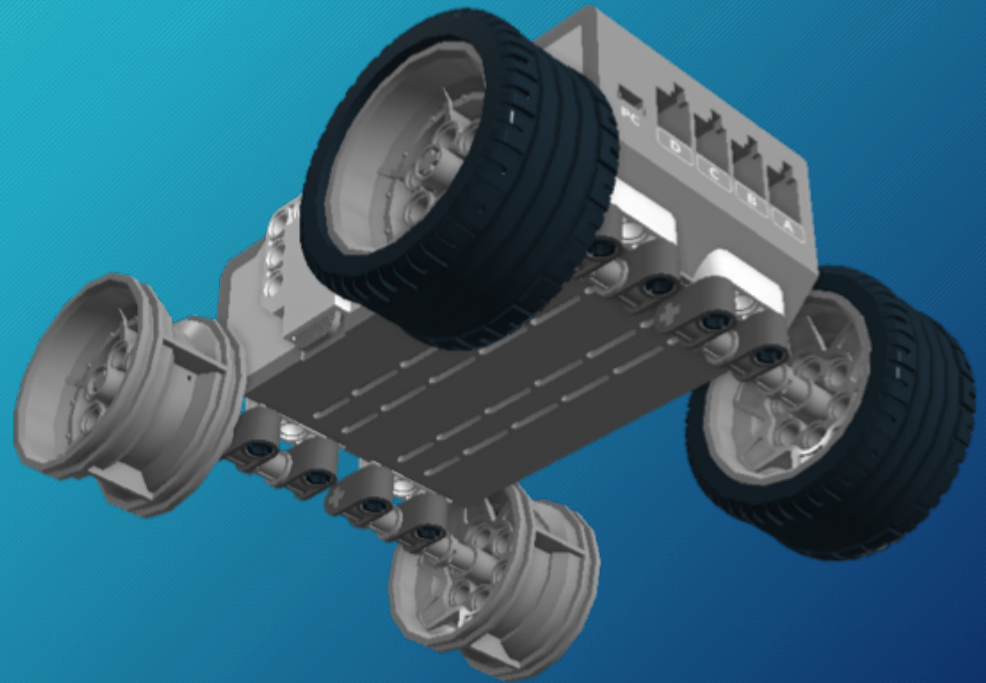
## Pivot turn right

Powering the left wheel while breaking the right will cause the robot to turn right.



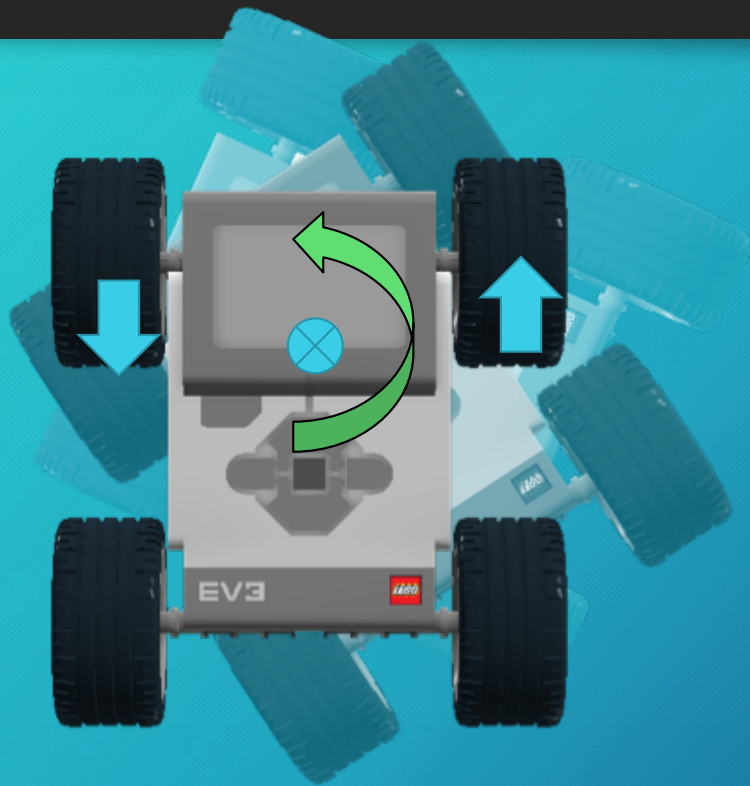
# Consistent Steering Tips

- Reduce friction
- Remove tires from rims
- Use EV3 caster in place of non-powered wheels
- Brake stationary wheel on pivot turns

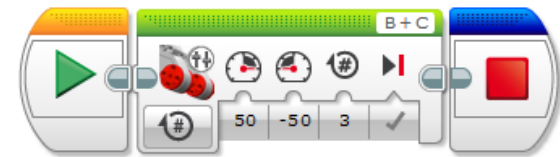




# Pinpoint turn

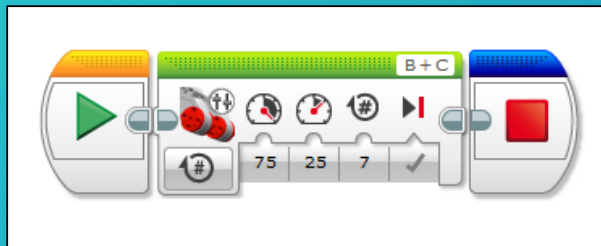


Powering the wheels in opposite directions will rotate the robot around the mid-point of the axle.



# Curved turn

Powering one wheel less will turn the robot in the direction of that wheel.  
The greater the difference in power the more the turn.





# Navigation methods

- Wall following
  - Horizontal guide wheels
  - Approach wall at shallow angle
- Mounting sensors covered in Attachments and Sensors.
- Programming sensors covered in Programming Workshops including countering gyro drift.



# Navigation methods

- Line following
  - For greatest accuracy, box light sensors to eliminate (as much as possible) ambient light. Use the light generated by the light sensor itself
  - 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 - References and Tools

- EV3 Lessons: <http://ev3lessons.com/index.html>
- Techbrick: <http://www.techbrick.com/>
- Wheels: <http://wheels.sariel.pl/>
- Gears: <http://gears.sariel.pl/>

### CAD for LEGOS®

- LEGO® Digital Designer: <http://ldd.lego.com/en-us/>

## Online - Parts

- Lego Educational: <http://legoeducation.us/>  
Go to the "SHOP" menu and then select "LEGO Spare Parts and Accessories"
- Brick Owl: <http://www.brickowl.com/>
- Techbrick: <http://www.techbrick.com/>
- BrickSet: <http://brickset.com/browse>