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.
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.
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.

Improve

Create

Ask

Imagine

Plan
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

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

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?
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 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
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 LEGO®
• Techbrick: http://www.techbrick.com/
• BrickSet: http://brickset.com/browse