

Maine Robot Track Meets

2017

Welcome to the Maine Robotics spring robot Track Meets! Now in our 13th year of competition. This great program is open to any students who are enrolled in the 3rd to 8th grades during the spring of this year. Teams can use any LEGO or VEX IQ robot kit.

Official Description and Rules



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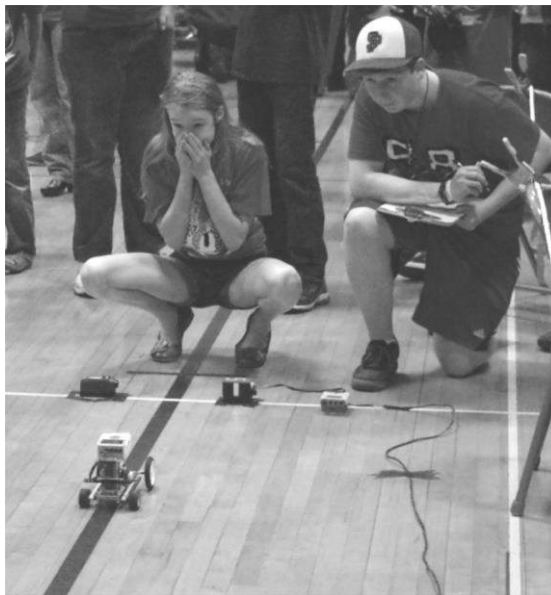
Maine Robotics
30 Main Street
Orono, ME 04473
207-866-4340

Revised: January 2017
Updated, Strongest: March 27, 2017
Updated, Slope Climber: March 30, 2017

General Information

2017 Dates

- **May 6th, 2017 - Messalonskee High School**
131 Messalonskee High Drive, Oakland, Maine 04963
www.rsu18.org/mms/
- **May 13th, 2017 - South Portland High School**
637 Highland Avenue, South Portland, ME 04106
<http://highschool.spsd.org/web/>
- **May 20th, 2017 - Ellsworth Elementary & Middle School**
20 Forrest Avenue, Ellsworth, ME 04605
www.rsu24.org/schools/eems/
- Several other sites may be added, they will be within the same date range as seen above (April 29th to May 20th) and any transfers may be made without charge if space exists.
- All registered teams will be kept apprised of any date and/or location changes. Notifications will be by email only
- All information will be posted on the website: <http://trackmeets.mainerobotics.org>



Track Meet Schedule

- ~~~~~ (times are approximate)
- 8:30 AM Doors open to teams and public
- 9:20 AM Coaches meeting with officials
- 9:30 AM Opening Ceremony
- 10:00 AM Competition begins
- 11:30 AM Lunch break
- 11:50 AM Competition resumes
- 1:00 PM Competition ends
- 1:20 PM Awards begin
- 2:00 PM Track meet complete

Note, the larger the meet (more teams and children) the longer the event will typically run. The events typically finish around 2 or 2:30, but have been known to go to 3 or 3:30 for larger events, or ones with larger numbers of entries in some of the slower events (like ping pong shot put or bridge)

Event List

- Slope Climber
- Table Clearing Mission
- Delivery Mission (new course)
- Fastest Robot
- Strongest Robot
- Bridge Building
- Ping Pong Shot Put
- Robot Speed Build
- Steeplechase (new course)
- Walker (new rule)



Order of Events

- Morning Events:
 - Starter events:
 - Slope Climber
 - Strongest Robot
 - Fastest Robot
 - Followed by
(as the starter events finish, each is replaced)
 - Table Clearing
 - Delivery
 - Steeplechase
 - Walking
- Afternoon Events:
Each run by itself, with possible earlier qualifier in case of high number of entrants.
 - Speed Build
 - Ping Pong Shot Put
 - Bridge Competition
- Awards

Gold Standard Awards

We will be awarding ribbons for teams that can meet the Gold Standards set for different events!

Slope Climber:60 degrees
Delivery Mission:25 seconds
Fastest Robot:3.5 seconds
Bridge:60 Pounds
Speed Build:3.5 minutes
Ping Pong Shot Put: 20 points
Strongest:40 pounds
Table clearing: 8 cans
Steeplechase: 40 points
Walking:20 seconds

A few words about the Meet

I used to run track as a youth, and I remember how each track was different. Some were compacted ash tracks, others asphalt, and others grass (now they have rubberized tracks too).

Each track meet would also be held in different weather. Once I remember running in the snow, sometimes it would be in the eighties, and sometimes in the rain.

The point being, each event was impossible to predict. Those who trained in the rain did better in the rain. Those who trained on asphalt did better on asphalt. The robot track meet is no different. I could get old(er) trying to make every team and group play on exactly the same playing field and not achieve such a goal.

Instead each team will have time to get “warmed up” and “acclimated” to the conditions at the meet.

Plan to use this time to change your programs for light levels or conditions different from your home track.

From the desk of
Tom Bickford
Director, Maine’s Robot Track Meet

Volunteers

- The Maine Robot Track meet is organized by Maine Robotics but depends on coaches and parents to volunteer on the day of the event to assist as timers and officials.
- Day-of-the-event training is available and each team should plan on recruiting at least one volunteer.
- Please treat the volunteers with respect, should you have an issue, please see the event organizer.

Scoring & Awards

- Awards will be given to each team winning an event.
 - If enough teams register for an event we will have 2nd and possibly 3rd place awards as well.
- Trophies will be determined by the number of teams pre-registered for the Meet.
- The overall winning team for the meet will be the one with the most points (Maximum possible overall score is 21 points – $7 \text{ events} \times 3 \text{ pts} = 21 \text{ pts}$)
 - 3 points for first place
 - 2 points for second place
 - 1 point for third place
- In the case of ties for equivalent overall scores for the meet the winner will be determined by the number of 1st places (or subsequently 2nd places, or 3rd places).
- Each team will be acknowledged
- All participants will receive an event t-shirt.
- ***Events will have “Gold” standards. If team members meet that level, they will receive recognition for meeting or exceeding that goal.***

Registration Requirements

- 1) The coach or similar adult must register the team and provide all required information and forms, including:
 - a) Team Name
 - b) Coach name(s) and contact information
 - i) Phone, email, address
 - c) Desired Meet Location
 - d) Event's being entered, number of robots, RCX/NXT/EV3/VEX IQ type
 - e) Names of all team members **and t-shirt sizes**
- 2) Registration payment must be received (postmarked, paid, or purchase order). Registration covers participation in the 2017 Robot Track Meet season; all coach and team support during the spring season; and participation at one (1) of the Robot Track Meets.

No Increase
For 2017

 - (a) Regular Registration: (\$45/team member) on or before April 1st, 2017
 - (b) **Late Registration: (\$55/team member) after April 1st, 2017**
 - (c) Additional track meets: Your team can attend an additional track meet, if space is available, for an additional (\$35/team member). No additional shirt included for second meets.
- 3) Signed and returned release forms for all participants
- 4) Registrations received after April 16th, 2017 may not receive t-shirts due to needing to put the order in... so plan accordingly. If we have extra we'll pass those out, but no guarantee after the 4/16 date.



General Rules:

Basic Guidelines

- 1) Event registration
 - a) A team may register for any number of events, up to 7 entries
 - b) This could include all robot events, all non-robot events (bridge) or a combination of the two
- 2) Team Composition
 - a) A team is not limited in size.
 - b) All members of the teams must be currently enrolled in grades 3 to 8, including home-school or alternative school settings.
 - c) All members must have a signed consent and release form to participate in the track meet.
 - d) Local teams may be organized as part of a school's curriculum, after school program, a home school program, a community activities program, a neighborhood/family group, or any other group providing the team is coached by an adult over 18 years of age who is acceptable to the parents/school/group in their own community.
- 3) The Maine Robot Track Meet is designed to evaluate finished products in the form of robot performance or LEGO/VEX IQ structural design.
 - a) In this respect it is very much like a track meet.
 - b) Robots may be of any shape or variety as long as they meet the robot rules outlined in that events' section as well as the general rules section.
 - c) Programs, individual building styles, team work, or other important aspects are **NOT** part of the Track Meet. All criteria are based on the ability of the robot to perform under specific challenges.
 - d) Work must be completed by the team members

It is required that the work and programming of the robots be done by the students. Mentoring is allowed by adults, but ownership of the building and programming is expected to remain with the team members. When in doubt, demonstration of this ownership may be required to retain eligibility in the meet or event.

Entering Events

Each team may enter 7 events

Examples:

- One robot in 7 different events

- Seven different robots in the same event

- 3 robots, 2 in the fastest, 1 in the strongest

- 2 robots, 2 in the fastest, plus a bridge

- 3 bridges, 4 robots

- Any combination as long as no robot/bridge is entered in the same event more than once and that the total entries are less than or equal to 7.

Having a robot entered in more than 1 event may result in scheduling conflicts at the meet.

While we attempt to accommodate, the meet schedule will not be changed to make this possible. Strongest and slope climbers typically take a long time and these robots may not be entered into other events (either directly or through shared controllers).

If you have a lot of robots, split into *two teams*. There is no financial penalty and then you can have more entries! Two teams can have a total of 14 entries (2 x 7)

This rule is intended to allow smaller schools/groups a fair chance to compete against larger schools/groups.

General Robot Rules

1. A team/school/group may bring more than one robot.
 - a. Most events will not have compatible robots. For example, a robot that is the fastest will not likely be able to compete as the strongest.
2. The robot must be a single unit; connected by hard LEGOs or VEX IQ pieces (not wires, elastics, or string).
 - a. However, joints, swivels, or other mobile parts are allowable.
 - b. Projectiles, launchers, tethers, or remote units are not allowed. When in doubt, build a better robot, not a better gizmo. With the exception of the Ping Pong Shot Put in which case the ping pong balls must, by the nature of the event, leave the robot.
3. A robot may only be used by one team for one event. So a school with 2 teams may not use the same robot by both teams to run the fastest robot. They can, however, have two identical robots as long as they can satisfy the ownership requirements (demonstrate they built/programmed the robot)
 - a. Robot brains may be swapped between teams and team groups as needed to power different robots. So an NXT/EV3/VEX IQ could be used for the fastest in the morning and the ping pong shot put in the afternoon.
4. Check specific event for allowable arms, parts, and strategies.
 1. Event specific rules supersede these general rules.
5. Equipment:
 1. Each robot must include a LEGO RCX, NXT, EV3 or VEX IQ controller.
 - a. Each robot may contain only a single RCX, NXT, EV3 or VEX IQ controller.
 - b. The number of motors and sensors allowed is not dictated. However, all motors and sensors must be unaltered from their original LEGO or VEX state.
 - c. No glue, adhesive, or other foreign parts are allowed.
 - d. LEGO robots may only have LEGO parts.
 - e. VEX IQ robots may only have VEX IQ parts.
6. Robots may not be altered between heats to obtain better results, broken or damaged robots may be repaired.
 - a. For example: A robot that can go up a 60-degree slope must also be able to go up the 30-degree slope. A robot capable of pulling 40 pounds, must also be able to pull the 10 pounds.
7. Robots must start behind, or within their respective starting spaces. For those with finish lines, the robot is said to have crossed the finish line as soon as any part of the robot body has passed the finish line.
 - a. The part of the robot directly behind the starting line is generally considered to be the part that needs to cross the finish line. Arms or other devices designed to extend beyond the robot after starting are not considered to be part of the robot body.
 - b. For the Ping Pong Shot Put, see details under that event.

General Robot Rules (cont)

8. Power:
 - a. No AC power adapters may be used on the robot (during competition).
 - b. No external power supplies may be used on the robot (LEGO does make some)
 - c. Batteries and power used may not exceed 1.5 volts per AA battery or 9 volts total.
Winning robots may be required to submit their robot for evaluation of battery supply.
 - d. No power may be supplied from LEGO or other wind up, pull back, or elastic powered, devices. All power must be from the allowed motors and on-board power supply (RCX/NXT/EV3/VEX IQ)
9. LEGO or VEX weights are allowed
10. Communications during competition:
 - a. No communication is allowed between the team and the robot during competition
 - b. No IR Tower, Bluetooth or WiFi communication
 - c. No RCX/NXT/EV3/IQ to RCX/NXT/EV3/IQ communication
 - d. No Remote control devices of any type, wired or wireless
11. Sensors:
 - a. Each event will specify if it requires the use of sensors. If an event requires the use of sensors and they are not used, or not evident in their use, the officials may require a demonstration of the use of said sensors and disqualify if it becomes apparent that a robot is operating by dead-reckoning in an event that requires sensor feedback.
12. Delay:
 - a. Robots must have a built in delay of at least one (1) second between pushing the run button and the robot commencing operation, (see Figure 1). All times are measured from the time the robot crosses the start line (or leaves the start box). This one second time must be used by team members to remove all hands from the vicinity of the robot.

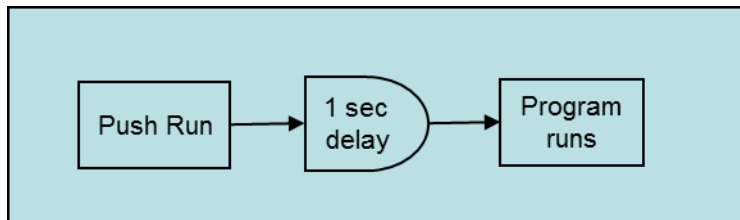


Figure 1 - Start Program Requirements

Suggestions

- As with all activities it may be necessary to find people to help out. Someone with carpentry skills can easily make the playing field elements.
- Bricklink.com is an excellent source of spare parts (or to sell spare parts), they have over 325,000,000 pieces of LEGO for sale from other LEGO enthusiasts like you!
- And remember, if you aren't having fun, then you and your team are missing out!

Terminology

Meet: Refers to the entire day's activities

Event: Refers to each of the 10 different activities

Trial: Refers to multiple opportunities within each event to get your best performance

Robot: A robot controller (RCX, NXT, EV3, or VEX IQ) plus motors, plus building components, plus battery supply, and including the programs running on the unit

Knob: LEGOs bricks and plates are measured by the number of knobs, also called studs, which is what LEGOs are covered with

Event 1: Slope Climber

The slope climber event is designed to focus on the following:

- a) Center of gravity
 - i) If your group doesn't understand this, it will not be able to make a successful robot to climb the slope
- b) Adaptability (must work at all elevations)
- c) Friction and traction (what works best to increase friction between the track and the robot)
 - i) Also cover static versus kinetic friction and which do they want?
 - ii) Relationship between friction and applied pressure (in this case weight from the mass of the robot in Earth's gravitational field)
- d) Gear ratios
 - i) How do you obtain the speed and control that is needed?
- e) Speed and stability
 - i) What characteristics are most important in a robot that can successfully perform this challenge

Climbing Competition:

- 1) Goal is to climb the slope at the robot's maximum possible angle
- 2) Rules:
 - a) Robot attempts to climb the slope at each prescribed angle until eliminated
 - b) Slope: (see Figure 2)
 - i) The Slope starts at 30° slope
 - ii) Slope is increased in 10° increments to 60° (30°, 40°, 50°, 60°)
 - iii) Slope is increased in 5° increments to 70° (65°, 70°)
 - iv) Slope is increased in 2.5° increments to 85° (72.5°, 75.0°, 77.5°, 80.0°, 82.5°, 85.0°)
 - v) Use of an inclinometer is required, either one such as the dial gauge inclinometer (See Figure 8) or available on many smart phones as an app.
 - c) Attempts:
 - i) Each robot has a total of three (3) attempts to complete a particular degree slope.
 - ii) Completing the climb is a successful attempt and automatically completes the attempt at that slope
 - iii) Failing to complete the climb at all three attempts at a particular degree slope will end the robot's competition
 - iv) Completed attempts will be marked with the time, in seconds, of the climb
 - v) Incomplete attempts will be marked INC
 - d) Timing/Scoring:
 - i) Each attempt may not exceed 75 seconds
 - (1) From the time the robot touches the start line to the time it crosses the finish line or is marked INC for an incomplete run
 - (2) Official may call the trial and mark as incomplete (INC) if robot has not crossed start line within 20 seconds.
 - ii) Score is equal to the highest slope climbed by the robot
 - iii) Time is the time from the robot crossing the start line to the time it crosses the finish line

- e) Platform
 - i) The platform is 24 knobs wide x 132 knobs long (**inner dimension is 41.5" long** and 7.5" wide and covered in LEGO plates. (see Figure 3 and Figure 4)
 - (a) The start zone goes from knobs 0 to 36
 - (b) The travel zone is from knobs 37 to 120
 - (c) The finish zone is from knobs 121 to 132
 - ii) The walls of the slope are 1"x4" nominal lumber (3/4" thick and 3.5" in height)
 - iii) For construction guide, (see Figure 5, Figure 6 and Figure 7)
- f) Robot
 - i) May NOT exceed 36 knobs in length (or it will not fit behind the start line)
 - ii) Robot must start butted against the lower end of the slope
 - iii) May touch the sides but may NOT
 - (1) Clamp
 - (2) Grapple
 - (3) Or use opposing force on the walls to gain support from the walls of the climbing platform
 - iv) Robot may not be reconfigured between attempts
 - (1) Except that a robot may be repaired and
 - (2) The weight may be redistributed between trials to account for changes in center of gravity
- g) Scoring:
 - i) The robot that climbs the steepest slope is the winner
 - ii) If a tie occurs, then the robot that climbs the steepest slope fastest is the winner

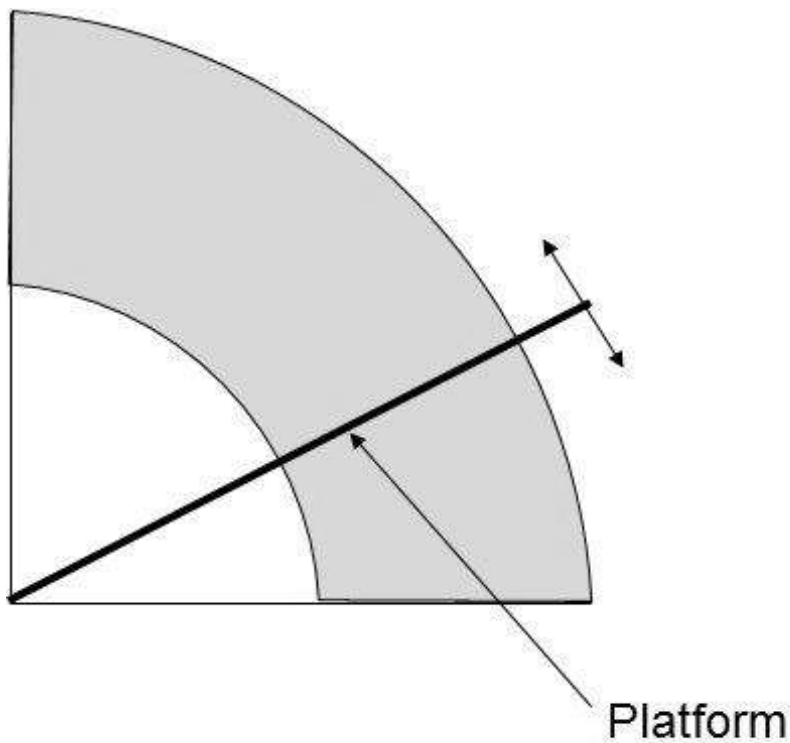


Figure 2 - Diagram of Slope platform movement

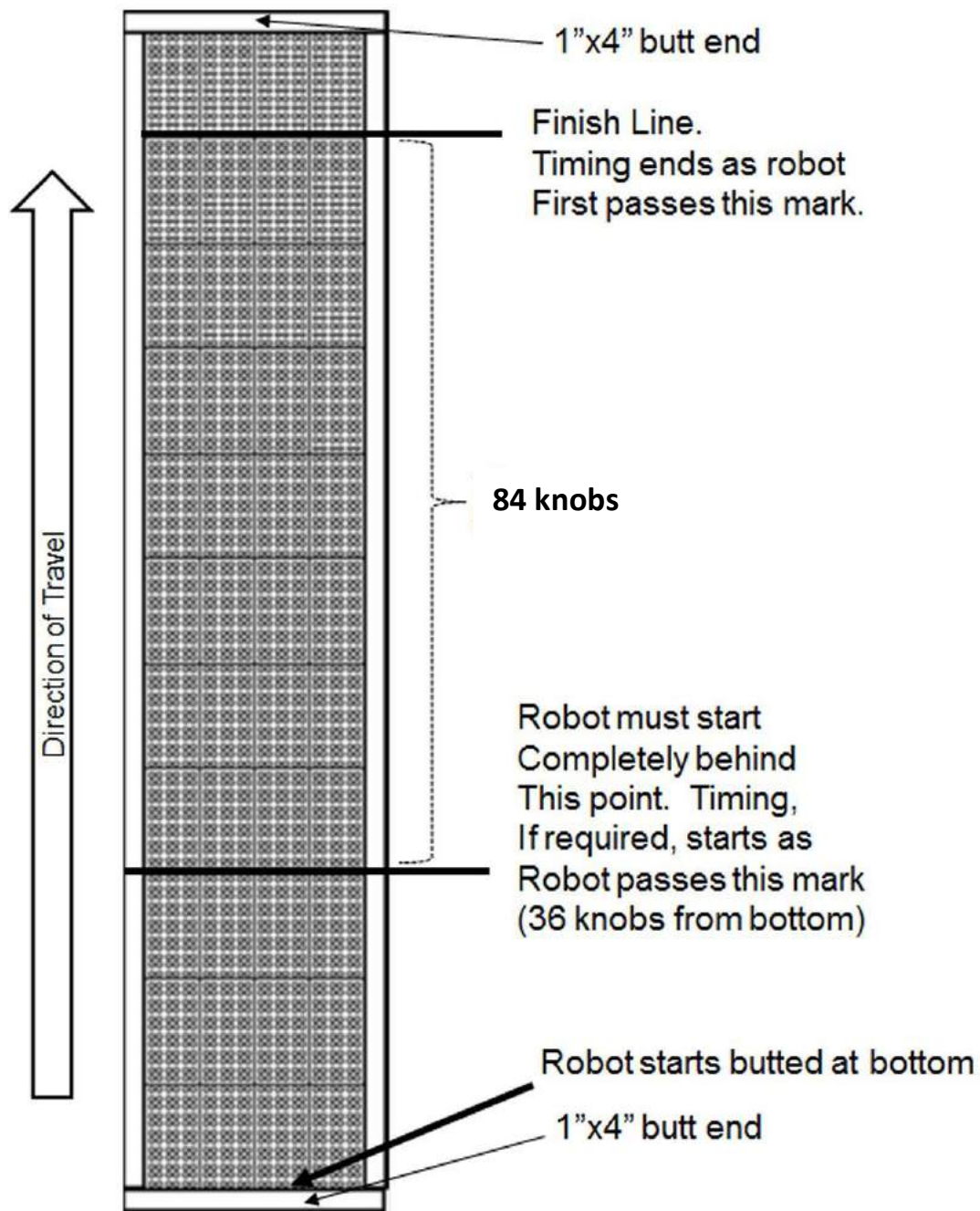


Figure 3 - Diagram of slope construction and slope zones

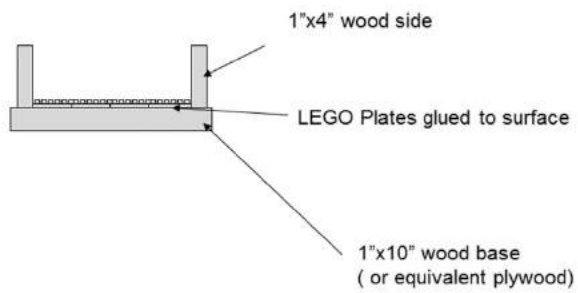


Figure 4 - Cross section of slope platform

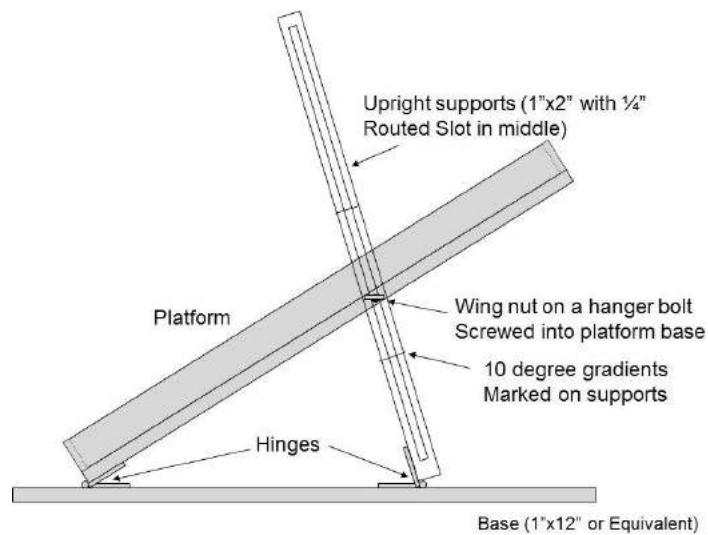


Figure 5 - Slope Climbing Assembly - side view

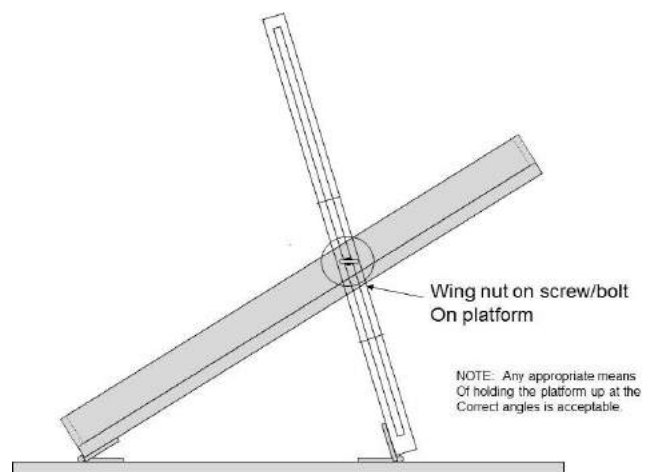


Figure 6 - Slope Climber diagram showing location of alternative bolt location

An alternative bolt system:

This is easier to make, however
Note that the carriage bolt head
Projects into the robot area of
The slope.

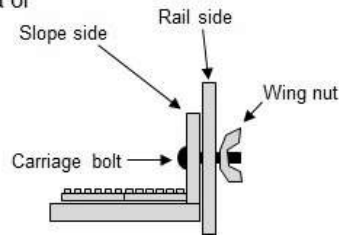


Figure 7 - Bolt system that Maine Robotics uses

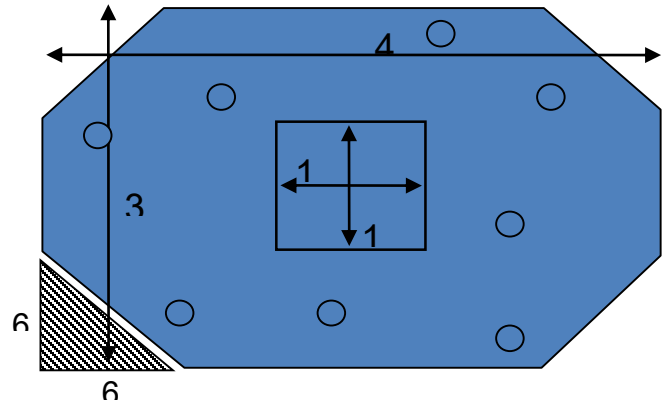


Figure 8 - Example of a dial gauge inclinometer and a smart phone inclinometer app.

Event 2: Table Clearing Mission

- Robot must navigate a table top surface without falling off
 - Robot must attempt to clear all 8 empty cans from the top of the table surface
 - Cans will be empty 12-ounce aluminum soda/juice cans
 - Placement will be noted at the competition (stays the same for the day)
 - 4 will be right of center and 4 will be left of center
 - 4 will be above midline and 4 will be below midline
- Sensors **must be incorporated** to perform this task
 - Robots that rely only on dead reckoning will not be qualified to perform in this event.
- Table top is 4' long and 3' wide
- Table top is white and has a 90-degree edge
 - The corners will be trimmed by cutting 6" x 6" triangles off each of the 4 corners.
- There are no borders or markings on the table top except for
 - A 12" square set in the center of the table
 - Square is made with a thin tipped permanent marker
- Robot must be started completely within the starter square
 - No extensions beyond the starting robot shape are allowed.
 - No extensions allowed after the start of the robot (what it starts as is how it should end)
 - Any moving parts must not exceed the total 12" x 12" maximum size allowance.
- Robot must navigate around the table without falling off or becoming stuck
- Scoring:
 - Each can is worth 1-point
 - Each robot will have 3 trials to remove the greatest number of cans from the table surface. The highest score will be used for the robot's ranking.
 - Highest score goes to the greatest number of cans removed in one trial.
 - If a tie exists as to the number of cans removed, then the following will be used for tie breaking
 - the highest total for the 3 trials will be used
 - The quickest – highest scoring trial
- A maximum of 90 seconds per trial is allowed.
- End of trial:
 - If the robot is touched by a human or falls from the table during its trial, then a 1 can penalty will be given.
 - There is no penalty if the robot stops on its own before 90 seconds has passed. Touching the robot ends the trial.
 - There is no penalty if the robot is still running at 90 seconds

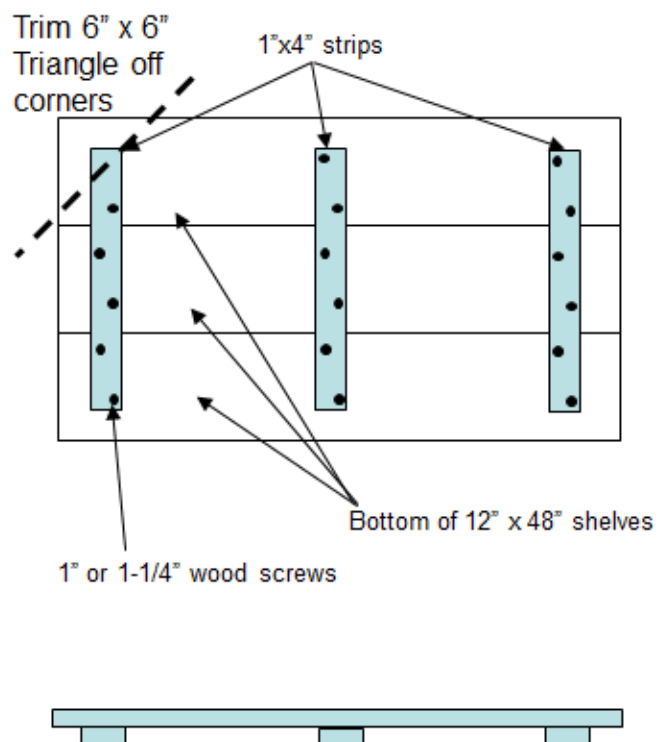
Light, touch, color, and ultrasonic sensors would be suitable sensors to stay on the field.
Use of either a grid-clearing program or use of ultrasonic
Sensors would likely be the best options for clearing the cans.



- Table construction may be made any way to meet the requirements.
 - The ones at the finals shall be made of $\frac{3}{4}$ " melamine with edges cut but not finished
 - The middle square will be measured to be a 1-foot square, perpendicular to the sides and equidistant from the two sides and top/bottom respectively (1 $\frac{1}{2}$ feet from each side, and 1-foot from the top and bottom)
 - Each of the four corners needs to have a 6" x 6" triangle trimmed off the corners.
- This event assumes that since the robot is using sensors to interpret its environment that slight differences in table size should not be a problem.
- If a robot depended only on touch or rotational sensors it would not matter what color a groups table was, only that it was of the appropriate size.
- Since each table may be different, and lighting conditions variable, each group must be prepared to adapt their robot and program to the circumstances of the match.
- Programming:
 - This event is more about programming and the integration of sensors than how a robot is built.
 - Come up with a flow chart of what you want to do and when you want the robot to behave differently.
 - <http://en.wikipedia.org/wiki/Flowchart> tells about what a flowchart is and how you might use one in determining what you want your robot to do.
 - In programmer's terms... think first, code second
This means you should know what you want to accomplish first, then think about how you will program to make that happen.

- At the local mega hardware store 12" x 96" white shelves were listed at around \$15
- At the same store a sheet of $\frac{3}{4}$ " melamine (49" x 97") was listed at around \$37 and would be enough for making all of the items needed for the track meet.
- So depending on your carpentry skills you may want to cut a larger piece down, or screw three smaller ones together.
- Remember, since this requires the use of sensors, there should be no reason the robot cannot accommodate a table that is not EXACTLY 36" x 48"
- Rough cut Melamine will have a rough particle board type edge while using shelves have a finished, laminate edge (depending on type of shelves purchased). This could make a difference to your robot. Again the ones at the meet will not have laminate edges.

Alternative way to make the table



Event 3: Delivery Mission (revised 2017)

This event is designed for both building and programming skills!

This year you have two options for your delivery. You can either select Target #1 which is closer but harder to deliver OR select Target #2 which is farther away but easier to deliver.

1) Rules:

a) Course (*New for 2017*)

- i) The course is laid out on a 93" x 45" field. We use the back side of an FLL playing field, but any smooth surface would work. (See Figure 9)
- ii) See figure 11 for details and dimensions
- iii) Two black electrical tape lines (3/4" wide) is provided as shown for those wishing to use a line follower leading to Target #1 and as warning line for when the robot is getting close to Target #2
- iv) A red electrical tape line (3/4" wide) is provided as shown leading to Target #2.
- v) The upright goal is used for delivering to Target #1
- vi) A low wooden barrier, attached to the mat, is used as a boundary for delivering to Target #2
- vii) Team uses one LEGO Object for the delivery mission

b) Robot must **carry** the LEGO® object and must drop it either

- i) Through the upright goal at Target #1 at the middle of the course or
- ii) Deliver it onto Target #2 at the end of the course
- iii) The team may **load the object** prior to the start of the run. The robot does NOT need to pick up the object.

c) Delivering the object

- i) The robot may use any delivery method to deliver the object, except as listed below:
 - (1) The robot may not throw or otherwise deliver the object from a distance greater than 6" from the target.
 - (2) The object may not be delivered over any of the divider walls

d) Qualification:

- i) Object is **carried** by robot to target
- ii) Object is dropped through target #1 opening or onto target #2
- iii) Dividers are in their original position
 - (1) Dividers have not been displaced from their starting position by more than 1/2"
 - (2) Dividers have not been knocked over
- iv) The Barrier before Target #2 is in its original position (*New for 2017*)
- v) Robot is not touching Target #2 (*New for 2017*)
- vi) Target #1 has not been knocked over or pushed completely out of its original start position
- vii) Robot remains on the playing area
 - (1) "Remains on" = all drive wheels/treads are in contact with the playing field at all time.

e) Score

- i) The score is based on being able to deliver the object AND the time to delivery of the object.
- ii) Score is the time from crossing the start line until deliver
- iii) Ranking will be based solely on time to complete this mission
- iv) There are no bonus points this year.

2) Upright Goal (see Figure 10)

- a) The target will be made of 3/4" thick wood and be 11-1/4" wide (a 1x12" piece of lumber from a lumber yard will give you this dimension)

- b) The base of the target is made from a 1x8" piece of wood (3/4" thick and 7-1/4" wide)
 - c) The entire target is 11-1/4" wide, 14-5/8" tall and 7-1/4" deep.
 - d) The vertical component is 2" back from the LEADING edge of the target assembly.
 - e) For practice, you could make this out of cardboard or plastic.
 - f) The target will be made of 1"x12" (3/4" x 11.25") nominal wood attached to a 1"x8" (3/4" x 7.25") base.
 - g) A 6" x 6" hole located in the horizontal center of the target and 6" from the ground to the bottom of the hole.
 - h) The base will be attached such that a 2" extension will be in front of the target face, so plan accordingly.
- 3) Barrier **(New for 2017)**
- a) Made from 0.75"x.75" wooden beam 12" long
 - b) Attached to the mat with 2 pieces of Dual Lock (Velcro like material, double tape could be used for practice).
- 4) Divider Walls
- a) Made from 1"x6" nominal wood and 1"x2" nominal wood
 - i) Nominal in lumber means that was its dimension BEFORE planing (smoothing the surface).
 - ii) So a 1"x6" piece of lumber ends up being 0.75" thick and 5.5" wide
 - b) Each divider is 12" long, 6.25" tall and 1.5" wide at its base
- 5) Delivery Object (See Figure 11)
- a) The delivery object may be made using any of the three described builds:
 - i) No loop
 - ii) Loop made with axles
 - iii) Loop made with flex tubes
 - b) Choice of object is made by the team

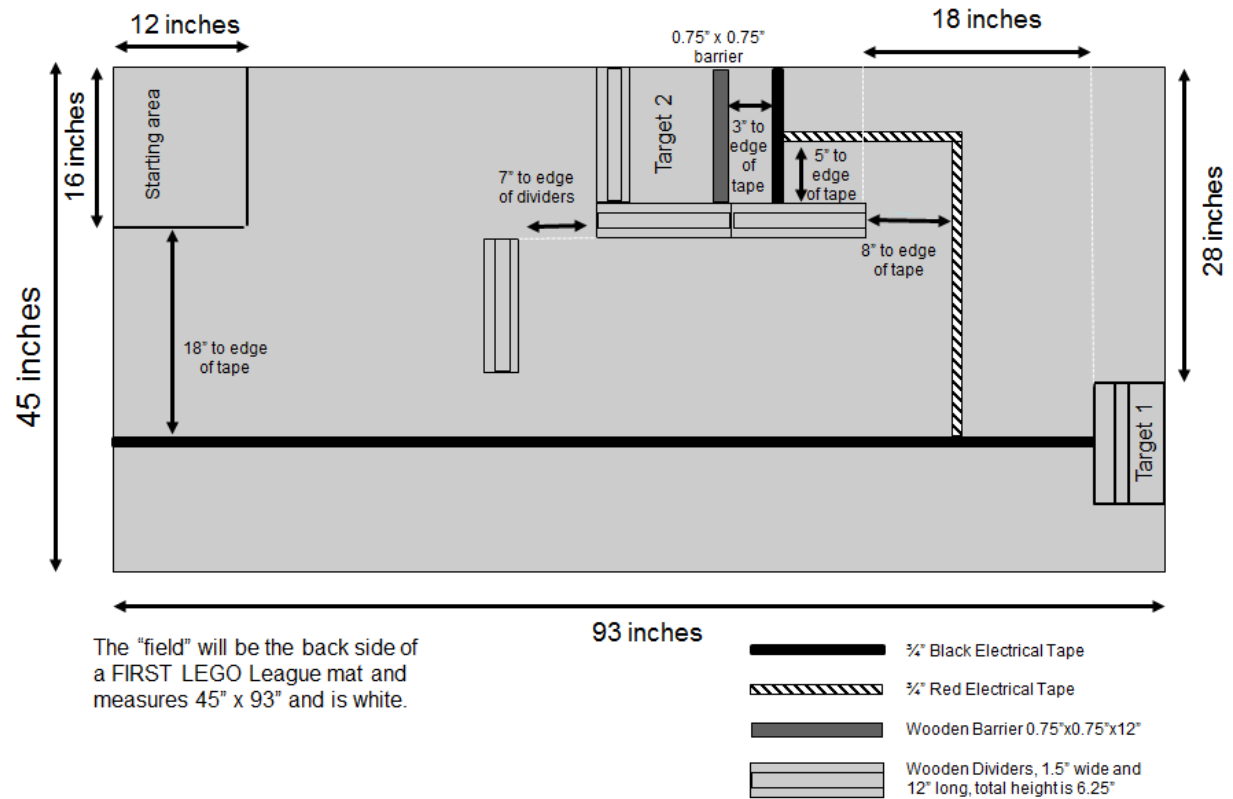


Figure 9 - Delivery Mission layout

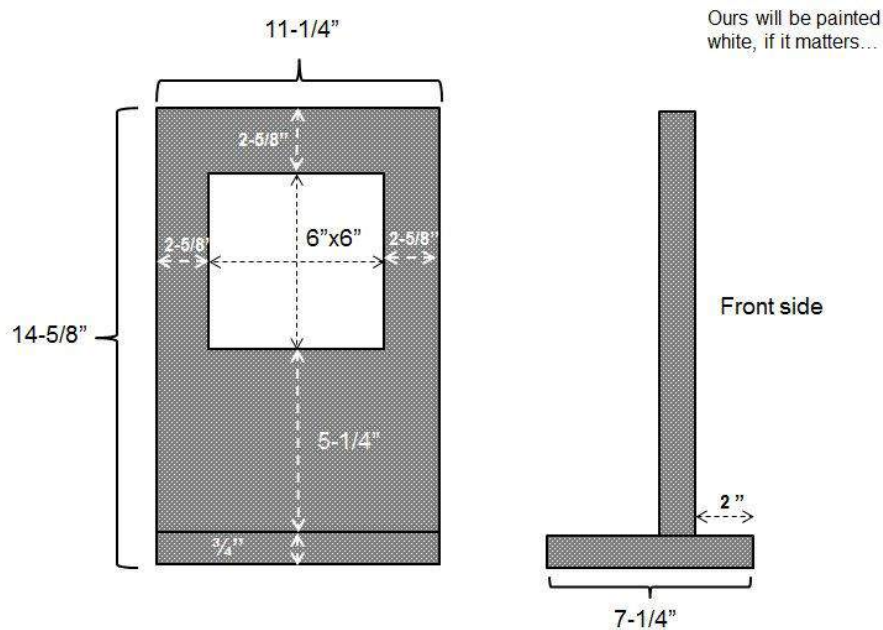


Figure 10 - Upright Goal dimensions

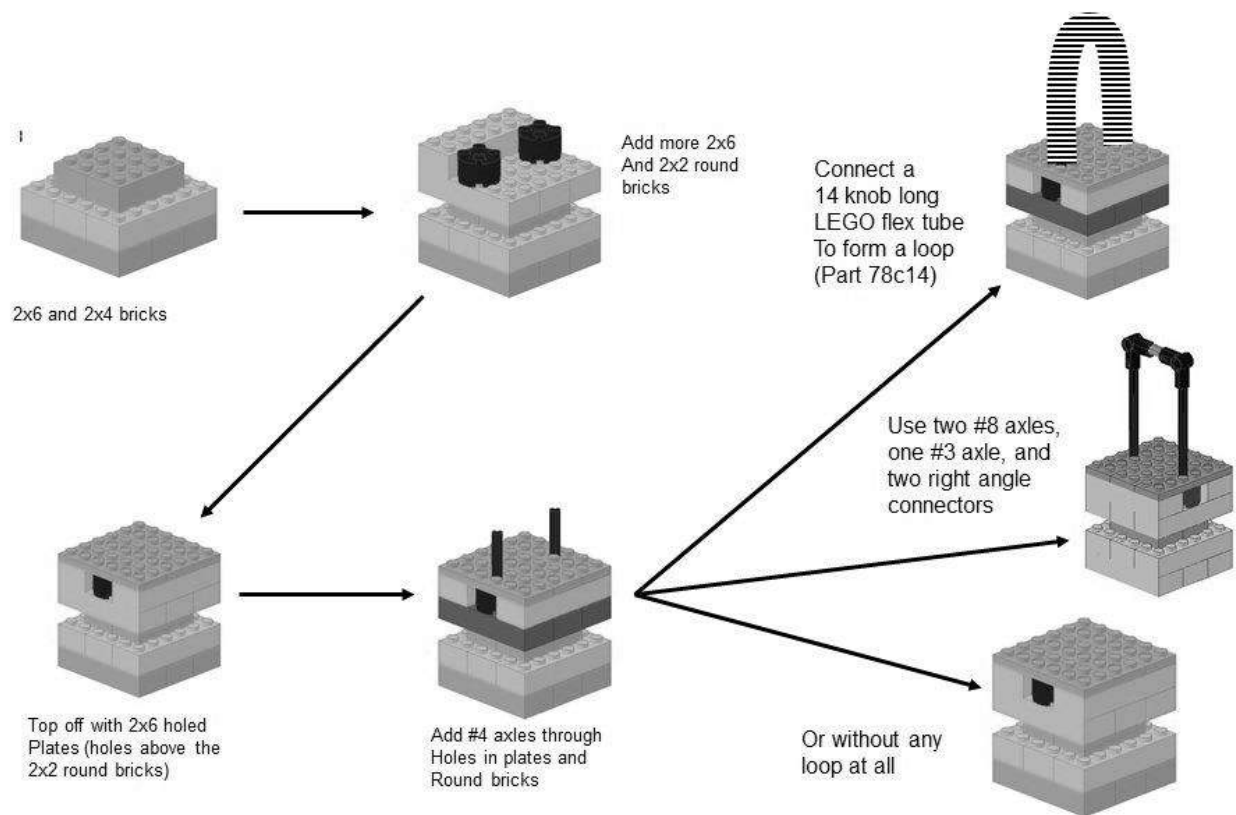


Figure 11 - Building the Delivery Object

Event 4: Fastest Robot

- 1) The fastest robot event is designed to focus on the following:
 - a) Relationship between the mass of the vehicle, the force generated, and the acceleration obtained.
 - b) Newton's three laws of motion
 - i) Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.
 - ii) The relationship between an object's mass m , its acceleration a , and the applied force F is $F = ma$.
 - iii) For every action there is an equal and opposite reaction.
 - c) What is the relationship between acceleration and velocity? Velocity and speed?
 - d) What is the relationship between mass and weight?
 - e) What is the relationship between force, power and work?
 - f) What about potential and kinetic energy?
 - g) What is energy?
 - h) Gear ratios on the robot drive system
 - i) Mass of the drive system
 - j) Power level of the batteries
 - k) Friction
 - l) Stability (must remain on course)
 - m) Robust design (shouldn't fall apart)
 - i) $F=ma$
 - (1) F =force delivered by the motors and powered by the batteries.
 - (2) M =mass of the robot and all parts
 - (3) A =acceleration of the robot when the force is applied.
- 2) More things to consider:
 - a) Adding motors increases the amount of force applied but also increases the mass of the object
 - b) In general, decreasing mass will increase acceleration
 - c) Power:
 - i) For these motors, force is directly related to the power level (in volts) of the batteries. So fully charged batteries = more force applied = greater acceleration
 - ii) The rechargeable batteries max out around 7.2 or 7.4 volts. While 6 brand new AA batteries (when possible) will give you 9.0 volts, and more power (until they wear down)
 - d) For these speeds air friction is considerably small in comparison to other forces; so barring having sails on the robot you can ignore air friction (air resistance)
 - e) We use laser lights and light sensors at the meet capable of measuring 1/100ths of seconds.
- 3) Rules:
 - a) Track: (See Figure 12)
 - i) The robot must transverse **18 feet** of floor
 - (1) Note: while we love metric, most school floors are still the 1-foot vinyl tiles and US tape measures are in feet... it is easier to measure out on the floor by feet. BTW 18' = 5.5 meters
 - ii) The robot must **pass between** two end pylons that are 4 feet (122 cm) apart at the end of the **18 feet**.

- iii) Robots that dislodge the pylons are disqualified for that heat.
 - iv) There are no markings on the floor for use as reference.
 - v) The starting line is a 1-foot-wide (30 cm) line, parallel to the finish line and **18 feet** away from the finish line.
 - vi) The robot must start between the start and back lines (12" or 30 cm) and be no wider than 12"
 - b) Timing:
 - i) We use two light sensors (you can use color sensors too) and two Laser level markers (note lasers can damage eyes) Check eBay for: Portable Laser Edge Straight Line Measure Tool, they have these for about \$4-5 each (you need two) and they run on AAA batteries
 - ii) You can either
 - (1) Attach both sensors to one controller such as an NXT or EV3 by "making" a longer wire (some soldering may be required) or
 - (2) Use two controllers and communicate between them.
 - iii) <http://goo.gl/HMfwCx> for building the light sensor trigger assembly and some simple programming directions (see Figure 13 and Figure 14)
 - c) Finishing the race:
 - i) A robot is said to cross the finish line when any part of the robot body passes the finish line, **without touching the end pylons and without breaking apart** (a loose piece that flies off a crashed robot and crosses the finish line does not count)
 - d) No sensors are required for this event.
- 4) Scoring:
- a) Is simply the time the robot takes to travel from the start line to the finish line
 - b) Best of three trials (not average or cumulative)
 - c) We use laser lights and sensors to measure the time and it is accurate to 1/100th of a second, but a stop watch is good for practice. See Figures 2 and 3 for device used to measure time.
- 5) Ties:
- a) Best average of 3 trials will be used to break ties
 - b) Lightest robot will win if all times are equivalent.
- Resources:
- 6) <http://science.howstuffworks.com/fpte.htm> is a good site to learn more, although they have more ads each year.

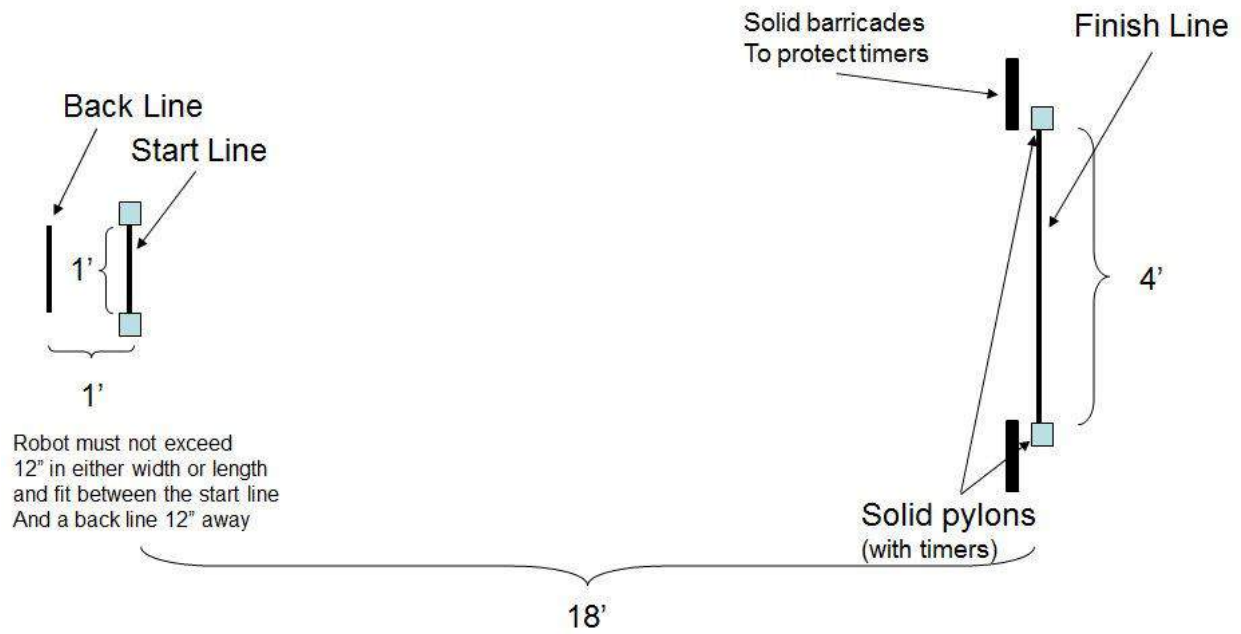


Figure 12 - Fastest Robot Course Layout



Figure 13 - Laser Light sensor construction



Figure 14 - Laser line level

Event 5: Strongest Robot (revised 2016)

- 1) The Strongest Robot event is designed to focus on the following:
 - a) Newton's three laws of motion
 - b) The application of gear ratios
 - c) The relationship between mass, weight, and friction
 - d) Integrity of mechanical structures
- 2) Rules:
 - a) Robot:
 - i) Must pull the cart, with weights, across the track
 - ii) There is no limit to the number of motors or wheels or tracks
 - iii) Robot-Cart Connection:
 - (1) In this instance a connection refers to a point where the two are in contact rather than a connection as often used in reference to LEGO pieces that have been coupled with knobs and holes.
 - (2) The robot may only connect to the wagon at the loop or loops and may only use LEGO or VEX IQ parts to make the connection
 - (3) MOST FAILURES OCCUR AT THE CONNECTION POINT, SPEND SOME TIME ON THIS BEFORE THE COMPETITION, (see Figure 18 for good example of connection)
 - (4) Robot wires, string or elastics may NOT be used for this connection
 - iv) Robot size:
 - (1) Robot must be no wider than 15"
 - (2) Robot, including cart attachments, must be no longer than 15" at all times during the competition.
 - (3) No mechanism may be used to extend the size of the robot either to the sides or the front in order to assist in crossing the finish line. In other words, the robot has to stay the same size throughout the event.
 - b) Track:
 - i) Robot must start between the back line and the start line (total of 15" between the two), (see Figure 15)
 - ii) Robot must pull the cart and weights from the start line to the finish line which is located 24" away
 - iii) Robot must have some part of its body pass cross the finish line between the two tape markers set 24" apart, (see Figure 15 and Figure 19)
 - c) Cart:
 - i) The wagon will have **three solid loops** at 1-1/2 inches from the ground at the center front of the wagon for use in attaching to the robot. The loop will have an inside diameter of at least 1-1/2 inches and will not be thicker than 3/8 of an inch. The middle loop will be on center with the wagon and the outlying loops will be 2.5" on-center to the left and right of the center. We use 1-5/8" diameter, 1/4" thick U bolts (available at hardware stores). (see Figure 16 and Figure 17)
 - ii) What a team uses for a wagon is immaterial except that equivalent loops be provided at the same height for practice
 - iii) Cart wheels are 2" to 2.5" hard, non-**pivoting**, non-bearing castor wheels. Available at most hardware stores for under \$4/each. Swivel wheels should not be used.

- d) Trials:
- i) Each robot shall have TWO (2) trials at each weight limit to successfully cross the finish line
 - ii) Time:
 - (1) Each trial may not exceed 60 seconds from the time the robot crosses the start line to the time it crosses the finish line, or it will be disqualified (marked INC)
 - (2) The official may call a trial (cancel and mark INC) if:
 - (a) Robot has veered off course and without question cannot cross the finish line
 - (b) Robot has failed to move after 20 seconds (wheels are spinning but robot has not moved)
 - iii) Trials shall start at 20 pounds
 - iv) Once a robot has successfully completed the course at a weight limit, the robots time to complete is noted and the robot is finished at that weight limit.
 - v) If a robot fails to successfully complete the course at a weight limit, the robot is marked INC
 - vi) Two incompletes at a weight limit will eliminate the robot from the competition.
 - vii) The weight will increase at 5 pound increments to **60 pounds** in an elimination competition.
- e) Scoring:
- i) The team that can pull the most weight wins
 - ii) If more than one team can successfully pull the highest weight limit, then the robot with the quickest time at the highest weight limit shall be the winners.
- f) Ballast:
- i) Each robot may use as ballast any LEGO or VEX IQ parts AND one or two 12 oz cans of DIET SODA in original and full condition (diet in case it spills is much easier to clean than sugared drinks)
 - ii) Ballast must be attached with only LEGO or VEX IQ parts and must be on the robot and completely off the ground.
 - iii) Any LEGO or VEX IQ pieces, including LEGO weights may be used as ballast, except
 - (1) No electronics other than those allowed under general rules may be used, so no extra robot controllers are allowed.
 - iv) Use of such ballast is completely optional.

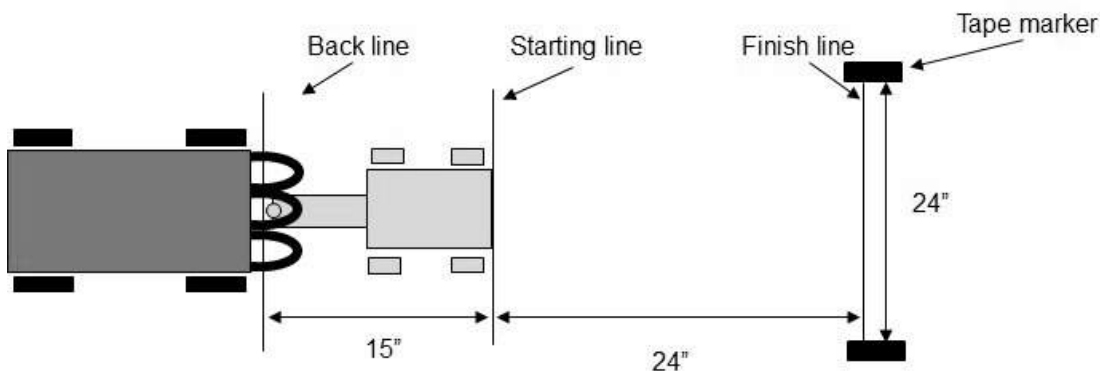


Figure 15 - Strongest Robot Course - Overhead view

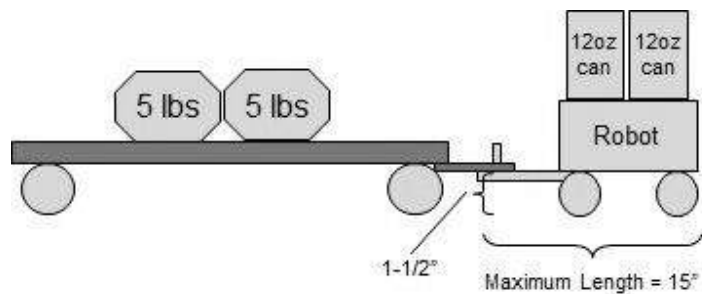


Figure 16 - Robot and Cart Configuration - side view

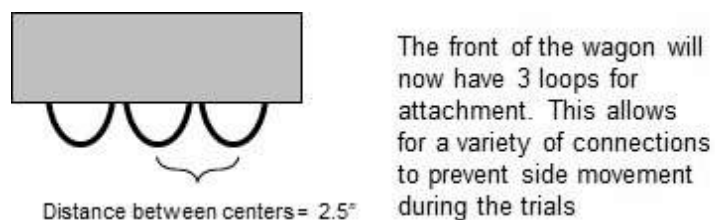


Figure 17 - Cart Loop Configuration

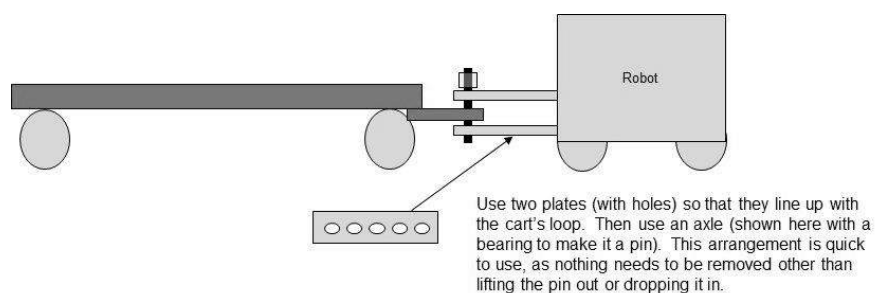


Figure 18 - Possible Robot-Cart connection

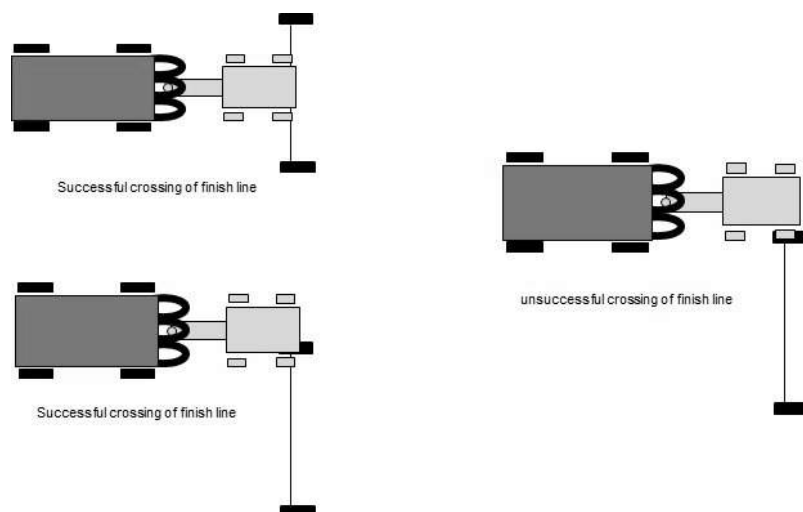


Figure 19 - Crossing the finish line

Event 6: Bridge

- 1) Background:
 - a) In the Bridge event, teams bring **pre-built** LEGO bridges to the competition for competition. Each year several bridges tested can hold all 180 pounds of weight without breaking (the amount of weight we usually have on hand).
 - b) It is also included as a non-robot event, allowing a team with limited electronic components to compete in an additional event.
- 2) Rules (see Figure 20, Figure 21, Figure 22)
 - a) Bridge must be built entirely of LEGOs
 - b) No electrical components are allowed (this is an engineering event not a robot event)
 - c) Any non-electric LEGO parts are acceptable for this event except you may not use string, elastics, wires, and hoses.
 - d) **The bridge must span 80 knobs (about 25 inches) so make sure the bridge is at least 92 knobs long!**
 - e) Loading Section:
 - i) The bridge must have a surface at the center of the bridge at least **48 knobs long and 24 knobs wide** for placement of weights on the bridge.
 - ii) The surface must be “paved” or otherwise constructed to actually hold the loads intended.
 - iii) The surface must be accessible for loading from above
 - iv) Since bridges can be loaded (in theory) with up to 80 pounds, consider how large a volume this would require and build accordingly.
 - v) The officials may disqualify a bridge, or stop testing, if it is difficult or impossible to load additional weight without the load falling off.
 - f) The team may stop at any weight to preserve the bridge from destructive testing, however, that would constitute a failure to continue (unless they are the only team left competing) and your highest weight held would be your weight.
 - g) Since the bridge may not use string or elastics as a part of the bridge it is expected that bridges will not be of the suspension variety. If there are any questions about this contact Maine Robotics for clarification.
 - h) **Each bridge will be tested until failure or 80 pounds**, whichever occurs first. Once a bridge has completed testing, the officials will move on to the next bridge. Additional weight may be added for **non-competitive testing**.
- 3) Bridge Supports:
 - a) The supports (stanchions/pylons/buttrresses) must be 24 knobs or greater off the surface of the table/floor or other supporting surface.
 - b) Support structures at the end of the span are provided and are 24 knobs wide and 6 knobs deep (see diagram)
 - c) The top of the support structures are at least 2 LEGO bricks high without any interference
 - d) A bridge end may attach to the support structure knob surface (top)
 - e) A bridge end may overlap the first brick of the support structure only (see Figure 20 and Figure 22)
 - f) The span of the bridge may extend down beyond the 1 brick limit as long as **AT THE SUPPORT** and **all AROUND THE SUPPORT** it does not extend below the 1 brick limit

- g) The span, with all loads applied must not touch the surface (table/floor) below the supports
 - i) If there is any question as to whether this is occurring a sheet of paper must be able to pass between the surface and the bridge span at all points and all weights
 - h) The support structures will be provided by Maine Robotics. You may bring your own for display, but the official supports will be used at the competition.
 - i) Note: The support structures may be built differently than shown here. However, any Alterations may not affect the inside span, the top surface, or the top two bricks of the Support.
- 4) Safety:
- a) All weight loading is done by Maine Robotics personnel.
 - b) All team members and audience members must be a minimum of 8' from the bridge during loading
- 5) Bridge Check-in
- a) Each bridge will be weighed at the beginning of the competition
 - i) There is no weight limit to the bridges
- 6) Winning:
- a) The bridge that can hold the most weight, up to 80 pounds, will be the winner
 - b) If more than one bridge can hold 80 pounds (a tie)
 - i) Then the lightest bridge will be the winner
 - ii) Weight is for the bridge only, not the support structures.
- 7) Reference: The bridge building event is designed to focus on the following:
- a) Compression and Tension
 - b) Force, mass, weight, and gravity
 - c) Comparative strengths of architectural design
 - d) Stress and torsion

Some Terms:

Tension is the opposite of compression where tensile force is being applied to stretch an object. The tensile stress is the amount of force and the tensile strength is the amount of force that the material can be subjected to without failing. Failure is usually represented by breaking, although it could also be a certain limit you do not want exceeded. Rope, wire, and chain are all good examples of materials that have tensile strength but no compressive strength. Steel and wood have tensile strength AND compressive strength.

Shear is the ability of an object to resist two forces in opposing directions applied against an object. Scissors work by shearing against an object. There is usually no change in volume of the object, but rather a displacement of the material. The earth's crust often has earthquakes when shear occurs in a plate or plates of the Earth's crust.

Torsion is the twisting of force around the axle of a material. Axles must withstand a great deal of torsional force without failing, otherwise they would break. Bolts are another example; if you over tighten a bolt with a wrench you may cause the bolt to fail by exceeding its torsion strength.

Elasticity is the ability of a material to change shape and return to its original shape after the forces have been removed. Rubber is an easy example, but steel, glass, plastics and wood all have elasticity. Imagine a tree that couldn't bend? Or steel springs that didn't bounce?

Plastic deformation is the result of material that is compressed/stretched/twisted beyond its limit of elasticity and you end up with permanent deformation (but without outright structural failure).

The Wikipedia has a good section on the strength of materials at http://en.wikipedia.org/wiki/Strength_of_materials.

The following websites have a good introduction to bridge design and principles.

<http://www.howstuffworks.com/bridge.htm>

<http://en.wikipedia.org/wiki/Bridge>

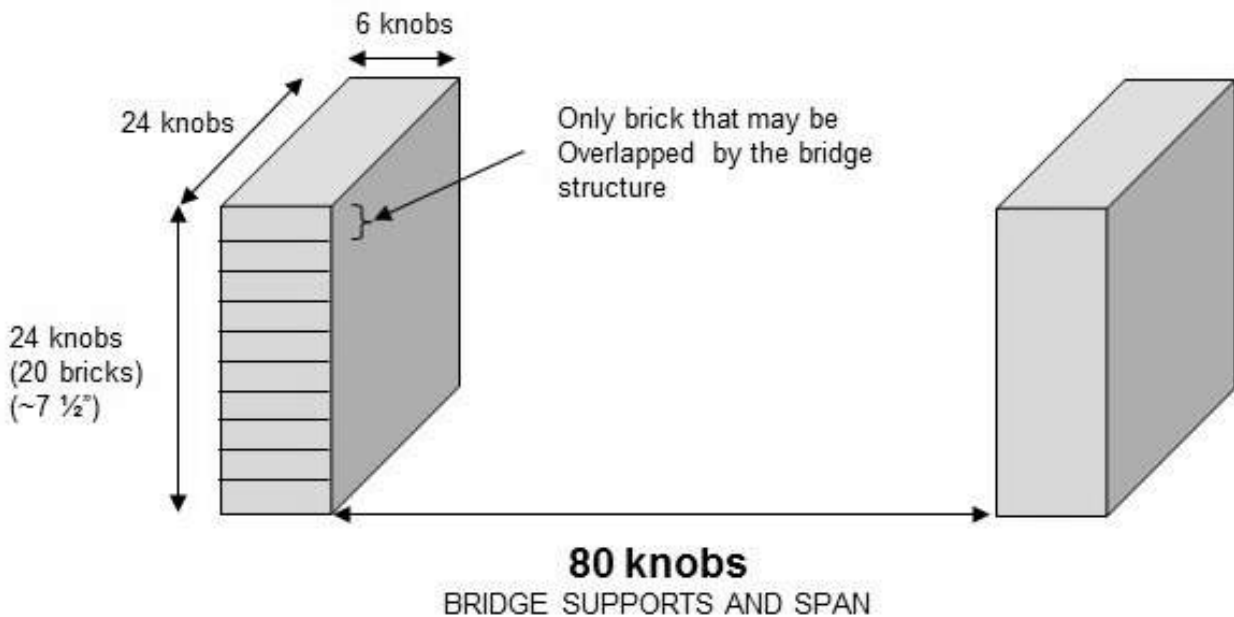
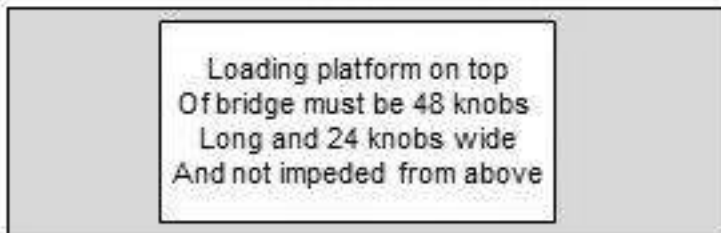


Figure 20 - Bridge Support and Span Dimensions

Sample bridge surface



Keep in mind that the officials and teams must load the Bridge with up to 80 pounds of weight (we use dumbbell weights, but you can use bags of sand or flour/sugar, etc)

Figure 21 - Bridge Loading Platform (on top)

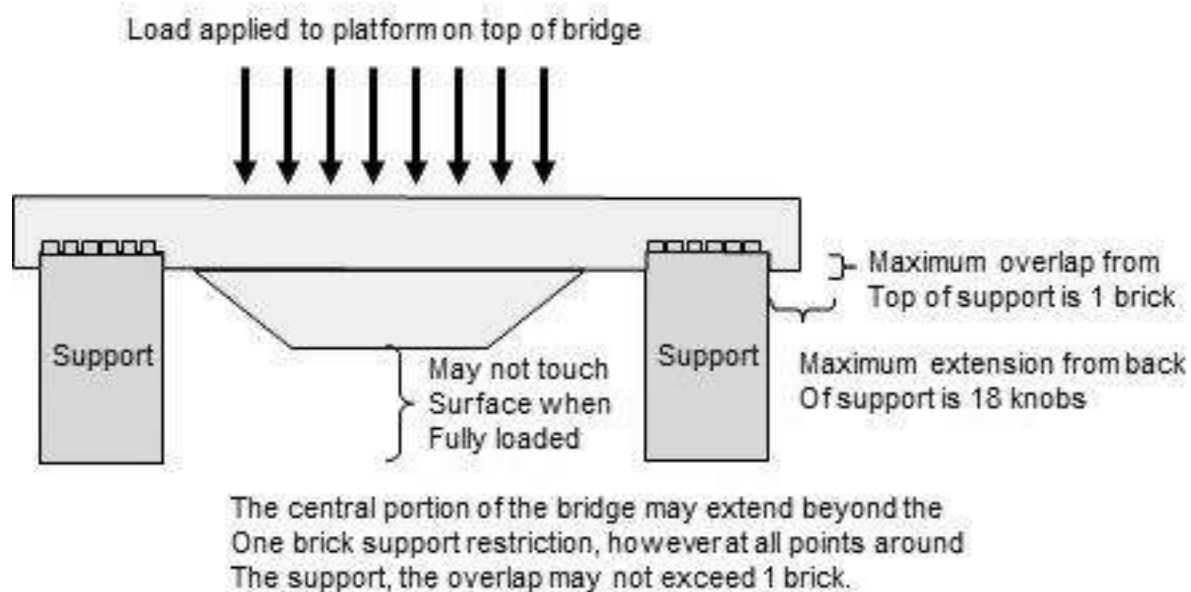


Figure 22 - Bridge Attachment and Layout

Event 7: Ping Pong Shot Put (revised 2016)

- 1) The Ping Pong Shot Put event is designed as an overall robot design project
 - a) What you will be doing:
 - i) Development of a system of components that can accomplish a task.
 - ii) Non-mobile robot (robot base doesn't move)
 - iii) Delivery of objects (ping pong balls) to a container.
 - iv) There will be only one (1) class of robot (auto feed)
- 2) Rules:
 - a) Timing:
 - i) Team has 2 minutes to setup, test, and align their robot.
 - ii) Team has 30 seconds to score as many points as possible
 - iii) Teams will have a standard
 - (1) "on your mark"
 - (2) "get set"
 - (3) "go" to begin
 - iv) After 30 seconds, score will be the number of ping pong balls in the receiving boxes.
 - v) If a ball is in delivery at the end of the trial's 30 seconds, but not yet delivered it will not count.
 - b) Number of trials:
 - i) There will be 3 trials for each team if 4 or fewer shot putting robots are entered
 - ii) There will be 2 trials for each team if 5 or more shot putting robots are entered
 - iii) Trials will be consecutive with up to a 2 minute reset period between the trials
 - c) Robot:
 - i) Robot must start completely **behind** the start line and may **not** touch the floor beyond the line or the receiving box at all at any time during the competition
 - ii) The robot must sit on the event surface (cannot be placed on boxes, etc.)
 - iii) Any arm or extension that extends beyond the start line must be completely retracted behind the start line between delivery attempts (1 ball per extension)
 - iv) The robot may not touch the receiving boxes at any time
 - v) You may no longer use any tape to secure the robot to the table, however a piece of shelf liner will be available to prevent slippage of the robots during the trials.
 - vi) Manual triggering:
 - (1) The robot launch mechanism OR the robot feed mechanism may incorporate a human operated trigger mechanism.
 - (2) Teams may use one (1) touch sensor to trigger a mechanism within the robot to allow the ball(s) to be feed into/onto the launching mechanism OR to allow the launch of any auto-fed balls.

- vii) Loading the robot:
 - (1) Ping pong balls are loaded on the robot prior to starting a trial. However as the loading mechanism is emptied more balls may be added provided the team members do not touch the robot or affect its behavior
 - (a) It is **REQUIRED** for a team to make some form of “ball hopper” to hold the balls for reloading and that the robot feeds itself.
 - (b) There is no limit to the number of balls held by the robot
 - (c) It is allowed to make replaceable ping pong magazines. Replacing these magazines would be the only time a team can touch the robot during its trial.
- d) The event setup (see Figure 23)
 - i) We will be using a finished (sanded) plywood base that is 2 feet wide and 8 feet long to place the ping pong shot put event onto. This will eliminate the problem of uneven surfaces, warps, etc. The surface will still be placed on a table to allow for easier access and better audience viewing. Please speak to the officials if you need yours to be run on the floor (still on the plywood), this will be allowed only on a case-by-case basis.
 - ii) The surface behind the start line will be covered in a foam coating to provide traction for your robot assembly. We will be using the foam shelf liner.
 - (1) **No tape will be used** as a result of this new method of preventing robot slipping.
 - iii) **Receiving box-low:**
 - (1) 4 sides
 - (2) 50 cm on a side made from 3/16” (5 mm) white foam board.
 - (3) Taped on all sides.
 - (4) Floor inside box will be lined with felt sheets (or equivalent), cut to fit.
 - (5) Attached directly to floor or table
 - iv) **Receiving box-high:**
 - (1) 4 sides and bottom.
 - (2) 25 cm on a side made from 3/16” (5 mm) white foam board.
 - (3) Taped on all sides
 - (4) The bottom will have a piece of cloth or foam to prevent “bounce-out” of delivered balls. Such anti-bounce material must be confined to the bottom inch of the box.
 - (5) The box is secured lightly to the floor with tape to prevent minor movement.
- e) Ping pong balls:
 - i) All Balls will be the standard Table Tennis diameter **40mm balls**.
 - (1) This will replace any existing 38mm table tennis balls.
 - (2) If you have 38mm table tennis (ping pong) balls, be aware that they may not behave the same as the standard 40 mm balls, particularly in that the 40 mm may jam in a space designed for 38 mm balls.
 - (3) Both the 38mm and the 40mm balls fit in a 5 knob wide x 4 block/1plate tall space.
 - ii) If a ball becomes “lost” it may be retrieved by the team and reused.
 - iii) The balls may be thrown, bounced, or dropped into the receiving box
 - iv) For the purposes of the meet we will be supplying the trials with 30 ping pong balls for delivery. If after practice you believe your robot can deliver more, please bring a supply with you for use at the meet.

- f) Scoring
 - i) 1 point for each ball delivered to the low receiving box
 - ii) 3 points for each ball delivered to the high receiving box
 - iii) Ties:
 - (1) If a tie occurs, the team with the greater total of points from all trials will be the winner
 - (2) If a tie still occurs, the team with the greater total number of points in the high goal box will be the winner
- g) Delivery Options:
 - i) Teams may incorporate any mechanism allowed by the rules, however here are some that have been used by teams in the past:
 - (1) Bounce on surface to goal
 - (2) Pitching Machine style
 - (3) Catapult
 - (4) Rotating striker (think t-ball)
 - (5) Linear striker (think pinball machine launcher)

3) SERIOUS CONSIDERATIONS:

- a) It is important for teams to work on this setup process
 - i) Can their robot be moved easily? We've had more than one robot fall apart in transit to the competition table
 - (1) Please note: we've had a lot of robots over the year that cannot be safely moved. It is part of your job to make your robot robust enough for travel from your team area to the competition area.
 - ii) How long does it take to setup, load, and zero in? You only have two minutes to get setup, load, and zero in your robot, so practice this at home/school and make sure you can do that.

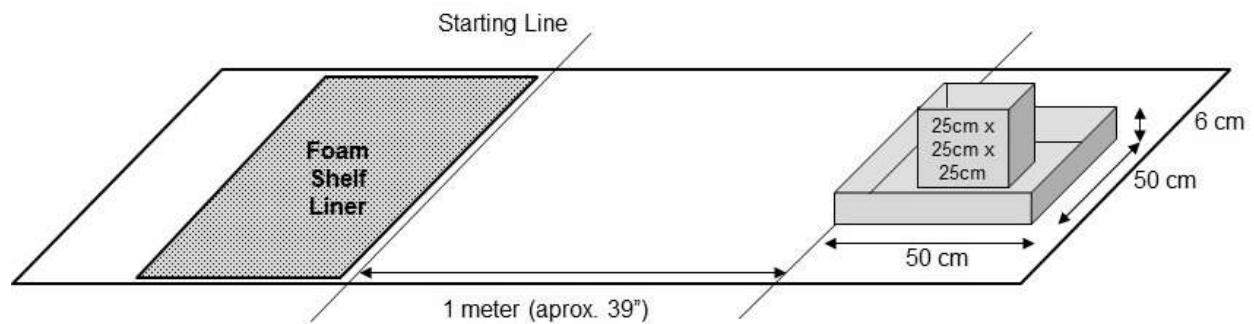


Figure 23 - Ping Pong Shot Put Course Layout

Event 8: Robot Speed Build

We added this event to provide additional opportunity for the contestants to show off building skills without tying up your robots on competition day

1) Rules:

- a) Each contestant **will be provided** with a container of parts for either the Simple NXT Robot or the Simple EV3 Robot.
 - i) Several extra bushings and black connectors will be in each container just in case some go missing.
 - ii) Competitors must inform officials if there are parts missing PRIOR to the start of the trial, so check quickly.
- b) Each contestant builds the **Simple NXT Robot** or **Simple EV3 Robot** during the match
- c) Directions for the Simple NXT or Simple EV3 Robot can be found at <http://trackmeets.mainerobotics.org> (see Figure 24 and Figure 25)
- d) Run the Program once the robot is built
 - i) NOTE: The robots will be programmed ahead of time to drive forward. You just need to build it and hit run.
 - ii) There will only be one program on the NXT or EV3.
 - iii) We highly recommend that you use your setup time to turn on your robot's brain so you don't need to wait for it to power up later.
- e) Robot must be completely built
- f) Robot must be built according to the specs in the online documents
- g) Robot must be able to drive forward
- h) All parts must be completely disassembled prior to the start of the round
- i) Setup Time:
 - i) Contestants may layout their parts prior to the start of the round (a one minute time will be allowed for setup)
 - ii) We highly recommend you turn on your robot at this time to save time later.
- j) No directions are allowed during the event
- k) Trials:
 - i) Each round will consist of:
 - (1) 1 minute setup (contestant may arrange, but not connect parts)
 - (2) 6 minute build and run (maximum time allowed)
 - ii) Each contestant will have two trials to get the fastest and most successful build
- l) Scoring:
 - i) A contestants time is from start until they are finished building the robot and it runs "forward" on the robot (move forward approx.. 1 foot)
 - ii) The best of the two trials will be used for the winner
 - iii) Ties:
 - (1) Should a tie exist the accumulation of both trials will be added and the lowest accumulated time will be the winner

1) Considerations:

- a) We've been building these robots here at Maine Robotics for some time now and we've timed ourselves. We can build the Simple NXT Robot in around 3:00 minutes. In our favor is that we've got LOTS of experience building; and against us is that we're getting older and move slower.
- b) **DO NOT ENTER THIS COMPETITION** if you have not practiced at home/school. This is a test of doing what you already know how to do.
- c) **DO NOT ENTER THIS COMPETITION** if your best time at home or school is greater than 6 minutes. We know pressure adds a lot to how fast you can go, but if you take 8 minutes to build this at home, you'll feel pretty bad when you get disqualified at the 6 minute buzzer.
- d) The world record is 2 minutes and 1 seconds! Set in 2014, go Paige!



Figure 24 - NXT Simple Robot



Figure 25 - EV3 Simple Robot

Event 9: Steeplechase (revised 2017)

Steeplechases are horse races that were cross country races that went from church to church with the steeples being the guides for the races, hence they would chase after the steeples.

Originated in Ireland around 1750 and is now a formalized horse race with standardized obstacles for the horse and rider to navigate.

The Steeplechase is a terrain obstacle course for your robot to travel over.

- 1) Rules:
 - a) Robot must start within the 1-foot x 1-foot starting square
 - b) Robot must cross/cover/navigate any obstacles between the start and finish lines
 - c) Rider
 - i) Robot must have a LEGO figure “rider” on its LEGO robot “horse” and the rider must finish the course without falling off.
 - ii) Rider may only be attached by standing or sitting on LEGO knobs
 - d) Time is measured from the crossing of the start line to the crossing of the finish line, or until it leaves the boundaries, which would result in the end-of-trial
 - e) End of Trial:
 - i) The robot leaves the course completely (usually falling off)
 - ii) The robot partially leaves the course and cannot get back on (hangs on the edge)
 - iii) The robot becomes stuck at a transition point (the pit or the peak usually) for more than a count of 10
 - iv) **A human touches the robot**
 - v) Team “calls” the trial, there is no limit on when the team can call the trial.
 - f) At the End of Trial, time and score are determined by the location of the End-of-trial event and time of the end-of-trial event, as described in 1)e) above.
 - g) Each robot has 3 trials to get the highest possible score or the fastest possible time
 - h) Wheels allowed:
 - i) NXT standard 56x26 drive wheels (tires part #55976, hubs part#56145)
 - ii) EV3 standard 56x28 drive wheels (tires part #41897, hubs part#56908)
 - iii) Other LEGO wheels with wheel diameter not to exceed 60 millimeters (2.375”)
 - iv) Wheel width is not restricted
 - v) Number of wheels is not restricted
 - i) Treads allowed:
 - i) No restrictions in 2017 for types or sizes of LEGO treads
- 2) Course: (see Figure 26, Figure 27, Figure 28, Figure 32, and 33)
 - a) A $\frac{3}{4}$ ” center line extends from the start, over the hill and on the landing for use with light sensors. Teams are also encouraged to use other sensors to avoid the edges.
 - b) See Figures 1 through 4 for details on the course
- 3) Score:
 - a) Base score (total):

i) Get all wheels/treads over the bump	10 pts
ii) Get all wheels/treads onto the hill and out of the pit (crossed the pit)	20 pts
iii) Climb the hill, reach the peak	30 pts
iv) Reach the bottom of the hill (New for 2017)	40 pts
v) Cross the finish line	50 pts

- b) Best of Three trials
- c) Ties:
 - i) Winner is the robot with the highest trial score (best of three)
 - ii) If multiple robots tied at the same score, then goes to the robot/rider with the lowest time to completion at the highest score for the event (likely 40 points).
 - iii) If there is still a tie, then it goes to the robot with the highest accumulative score (all 3 runs)
 - iv) If there is still a tie, then it goes to the robot with the lowest accumulative time (all 3 runs)

1) Steeplechase challenges:

- a) Going over the bump. You must make it over a 1.5" wide, 0.75" tall wood block that is 2.5" from the base of the slope.
- b) Make it over the pit and completely onto the hill.
- c) Climbing the hill. You must climb a 22° slope
- d) Overcoming the peak. You must transition from a 22° upslope to a 22° downslope without crashing, rolling, or losing your way. This transition is more difficult than many believe. A lower center of gravity will likely be helpful. Don't forget you can't lose your rider.
- e) Reaching the end of the hill.
- f) Crossing two barriers, 4" wide, 0.75" tall, and 0.75" thick. One is 3" from the end of the slope and 1" from the **left** side of the course. The other is 5.5" from the end of the slope and 1" from **right** side of the course. **(New for 2017)**
- g) Reaching the finish line.

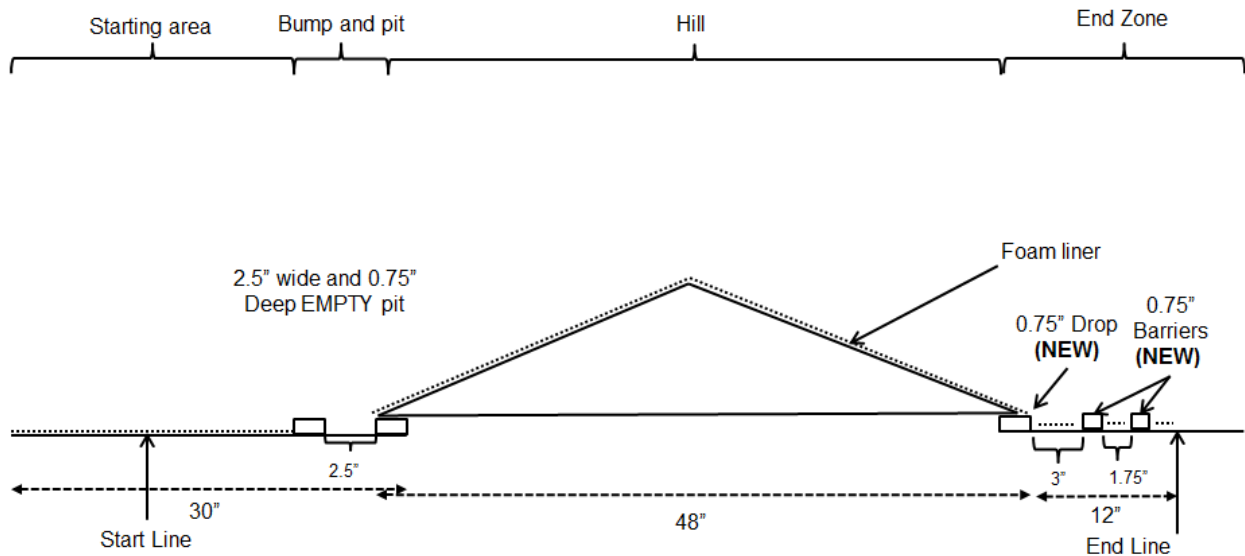


Figure 26 - Steeplechase Course - Side View

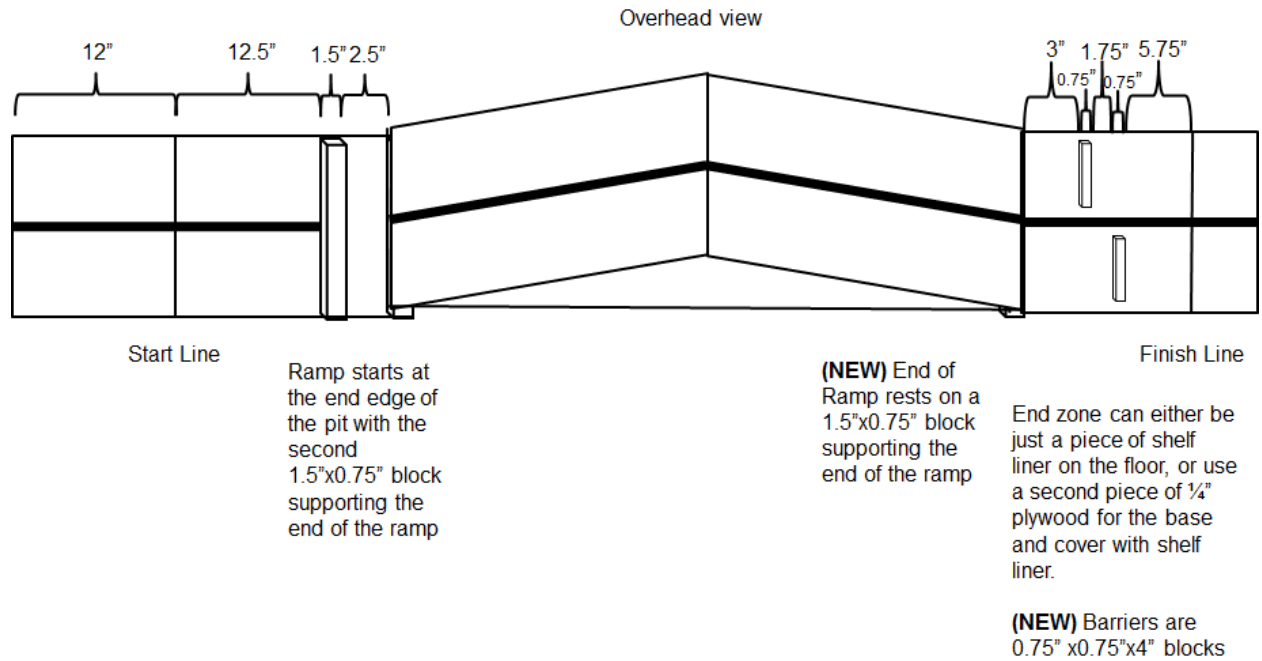


Figure 27 - Steeplechase Course - Overhead View

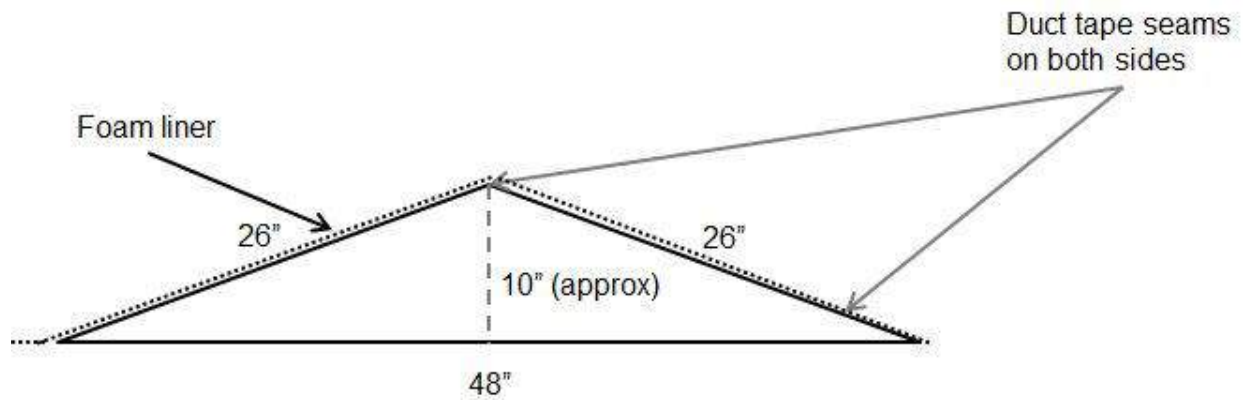


Figure 28 - Hill Detail

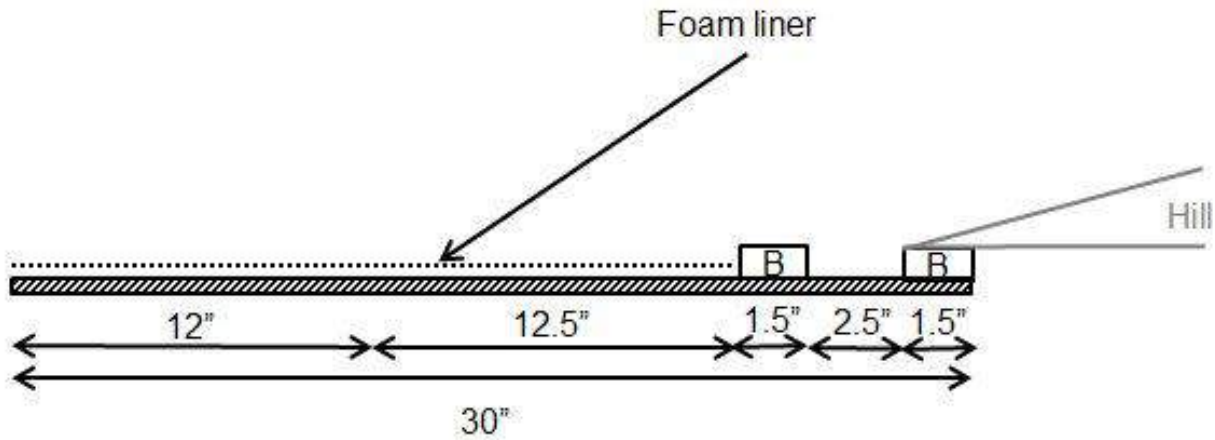
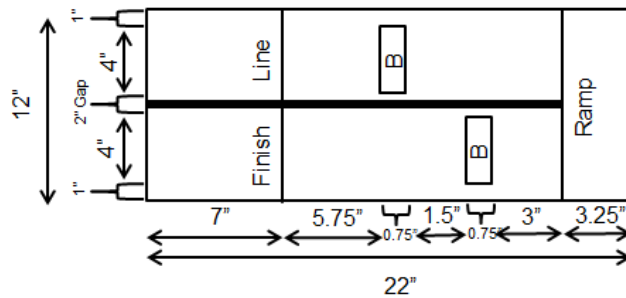


Figure 29 - Start and pit area detail



One 22" x 12", 1/4" plywood piece
(NEW) Two 4" x 0.75" x 0.75" wood blocks
 0.75" screws to connect wood together
 Duct tape to connect hill to landing (shown on left) and around edges of plywood

12" wide foam shelf/drawer liner on landing (we use Duck Original Easy Shelf Liner and glue it down with spray contact adhesive, but taped along edge would work as well).

Figure 302 – Finish line and barriers details (*New for 2017*)



Figure 313 - Making the parts from a 4' x 4' piece of plywood

Event 10: Walking Robot (revised 2017)

- 1) The Walking Robot challenges builders:
 - a) To understand more complex building challenges
 - b) The application of linear motion using weight distribution and balance, non-wheeled motive power, instabilities associated with a higher center of gravity
 - c) More complex programming
 - d) Integrity of mechanical structures
 - e) Please understand the difference between walking and flopping. Walking is good, flopping is not.
- 2) Rules:
 - a) Course (see Figure)
 - i) Course is on a 24" wide plywood surface
 - ii) Robot must cross a 36" long course
 - iii) Robot must start within a 15" x 15" square found behind the start line
 - iv) Optional side walls (think bowling gutter guards) may be used along the course **(New for 2017)** *Suggest you try these before competition as they can alter your robot's direction.*
 - b) Timing
 - i) Fastest qualified time wins.
 - ii) Time to transit the course is measured from the time the robot touches the "start line" to the moment it touches the "finish line" and must touch the finish line between the 15" wide markers. (see Figure)
 - c) Robot
 - i) Robot must have a one second pause at the beginning of the program
 - ii) Entire robot (RCX/NXT/EV3/IQ, motors, body, wires, etc) must be one unit
 - iii) Robot may not touch the ground with any wheels or treads that can rotate. Nor can any propulsion system rely primarily on extensions from wheels or treads.
 - (1) Wheels and/or gears can be used in a locked fashion or in a stationary flat position to allow for traction, but may NOT rotate around their axle while in contact with the ground.
 - iv) Robot is not limited to the number of legs or to the articulation style of the legs or mobility system, except as prohibited here.
 - v) Robot need not completely "lift" its legs from the floor to move forward
 - vi) Robot body may not touch the ground during the gait cycle, other than incidental touching (left to the discretion of the officials)
 - (1) A robot body may have some legs that are rigidly attached to the body while others are mobile
 - vii) To compete the robot must reach the finish line without being disqualified
 - (1) Must complete run within 60 seconds from time it touched the start line
 - (2) Must not be touched by humans
 - (3) Robot body must not touch the ground (see above)
 - (4) Robot may not fall over
 - d) Trials:
 - i) Each Robot shall have three trials to complete in the fastest time, as long as the robot is present at the time they are called to compete.

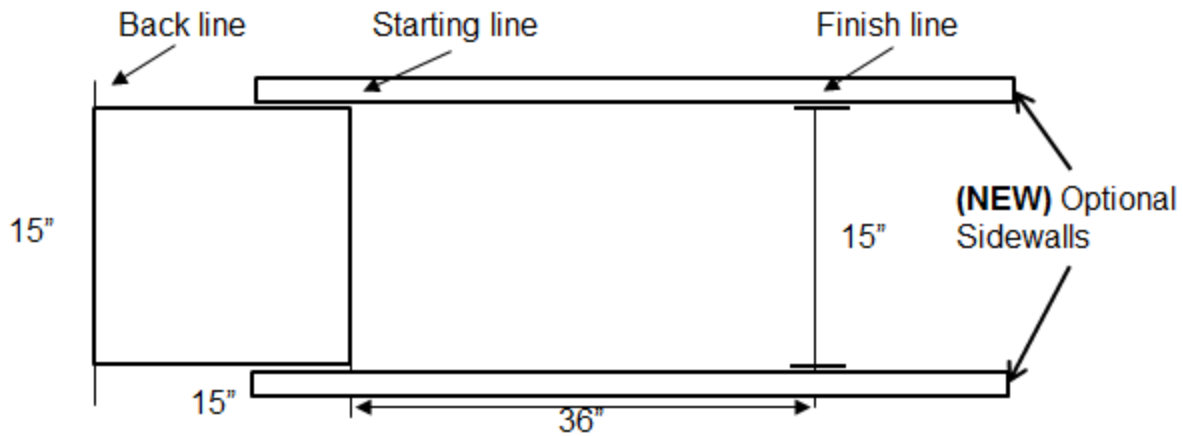


Figure 34 - Course Diagram

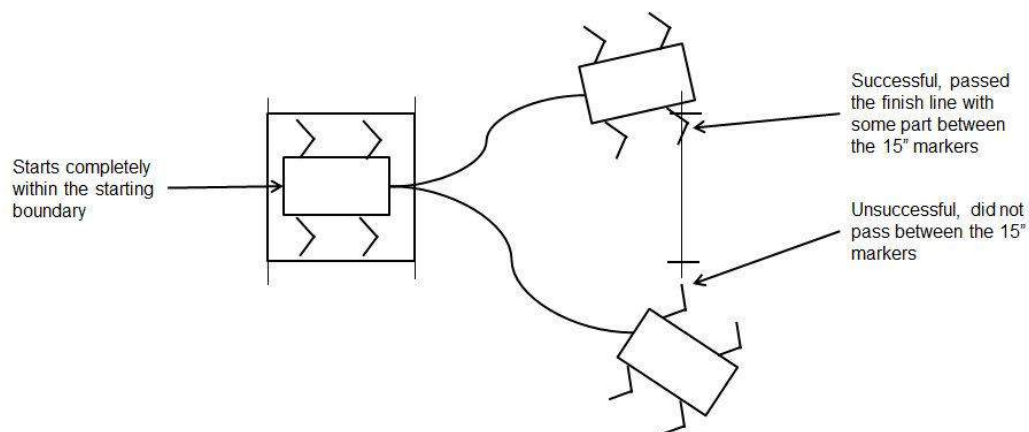
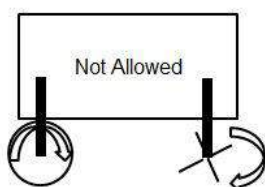
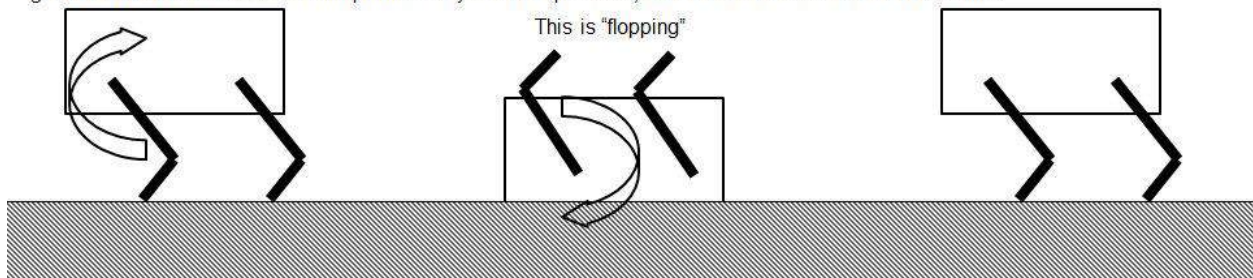


Figure 35 - Finishing Qualification

In this case the robot is propelled by rotating legs, but during part of the gait (walking cycle) the robot body rests on the ground and therefore would be disqualified. If you have questions, contact Maine Robotics for clarification.



No wheels, treads or any item that touches the ground may rotate around its axle as it's primary source of motion. Axle rotation to move legs is perfectly acceptable.

Figure 32 - Flopping and Rotating motions not allowed

Walking Terminology:

- **Gait**
The pattern of movement in limbed locomotion on solid surfaces (doesn't apply to fish). Examples include walking, running, galloping, hopping, jumping, trotting, etc. <http://en.wikipedia.org/wiki/Gait>
- **Stride**
A period of location for a specific limb, for example from the time your left foot touches the ground until it touches the ground the next time.
- **Linear motion**
Motion in a straight line
- **Rotation Motion**
around a fixed point or axis
- **Rotational speed** (or speed of revolution)
A measure of rotation in a unit of time. Often in revolutions per second or per minute (RPM or RPS)
- **Reciprocation or reciprocal motion**
Repetitive up and down or back and forth motion
- **Oscillation**
Repetitive variation over time
- **Leg (and Foot)**
A weight bearing and locomotive extension
- **Joint**
The location and structure where two bones or limb parts meet. Typically allowing rotational or angular variation between the different bones or limb parts

There are a number of walking robots found on the web and YouTube
Try searching for "LEGO Walking Robot" on YouTube to get some ideas

Some terms for discussing gait and stride:

<http://www.nopcoclinics.com/images/customer-files/GaitTerminology.pdf>

Biped, Triped, Quadruped, Hexapod, Octopod?? What form of design will you use?
Lift and move, shuffle, rotate?

<http://youtu.be/sAQS4NLEnEw> Robot Granny monopod with a walker!

<http://youtu.be/lmVQ2tmS1O8> 8 legged robot that can turn

<http://youtu.be/XdRzgwtMpUE> cool biped with balance

<http://youtu.be/R1jARHRn8e4> another 8 legged robot

<http://youtu.be/fa7IAvvYPOs> 8 legged spider bot that can turn

<http://youtu.be/SJEzOvWa--8> NXT2saurus, a biped turning robot

<http://youtu.be/ewtAUP6ifpM> 8 legged pneumatic robot (too big for us, but...)

<http://youtu.be/42udUfqTNTw> Cool 8 legged walker

<http://youtu.be/y2J3ZMDKDP8> Another biped, but without a controller

<http://youtu.be/O1pbXuWKbLI> Another 8 legger

http://youtu.be/BcKmvD_5Q-Q LEGO centipede (note, wheels do NOT turn)

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