20th Year!

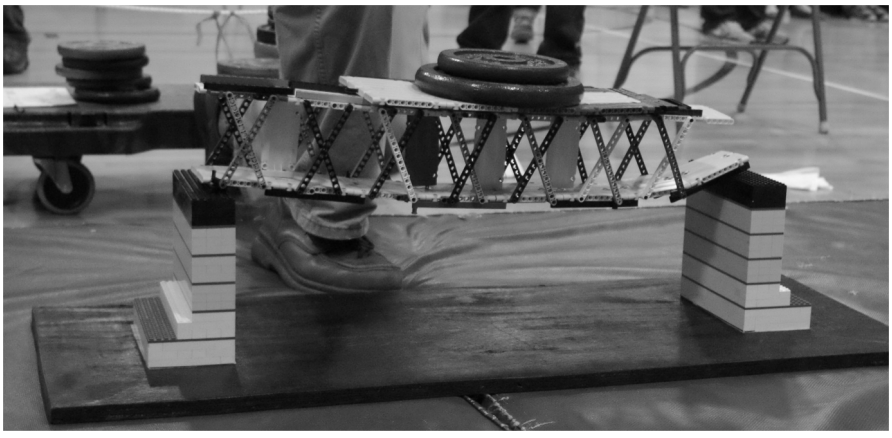
ROBOT TRACK MEET ASSOCIATION

What can YOU build?

Robot Track Meets 2024

Welcome to the Robot Track Meet Association track meet season! Now in our 20th 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® GO or IQ robot kit.

Official Description and Rules



Contents

Robot Track Meet Association
Attn: Tom Bickford, Director of STEM Outreach
University of Southern Maine
210 John Mitchell Center
37 Campus Ave
Gorham, ME 04038
207-780-5235 Office
207-735-3748 Mobile
thomas.bickford@maine.edu

Revision V1: 12/12/2023
Revision V2: 1/2/2024
Revision V3: 1/10/2024
Revision V4: 2/3/2024 – fixed general rule 2.c. & added this year's team fees.

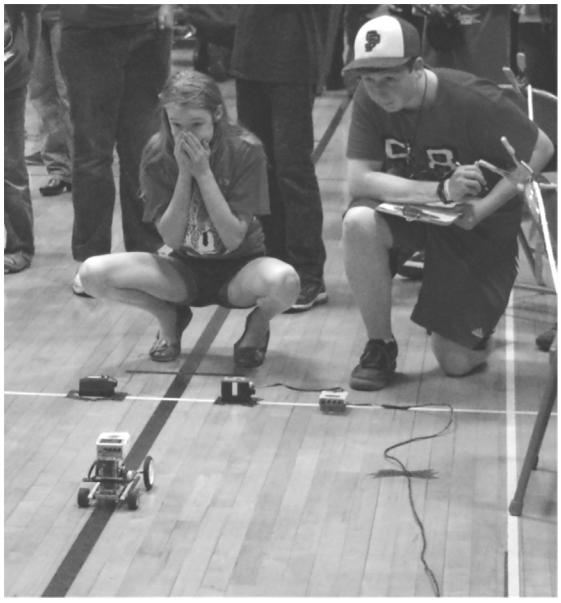
Section 1: General Information

2024 Dates

- **All Track Meets will be listed and available for registration on our registration website: https://www.robottrackmeets.org**

- All registered teams will be kept informed of any date and/or location changes. Notifications will be by email only

- All information will be posted on the website: http://www.robottrackmeets.org



Track Meet Schedule

Most track meets use the following schedule. However, you are responsible for checking with your local host to make sure they are not running an alternative 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
- 1:00-2:00 PM Competition ends
- 1:20-2:20 PM Awards begin
- 2:00-3:00 PM Track meet complete

Note, the larger the meet (more teams and youth) 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 (20th year!)
- Table Clearing Mission
- Delivery Mission
- Fastest Robot (20th year!)
- Strongest Robot (20th year!)
- Bridge Building (20th year!)
- Ping Pong Shot Put
- Robot Speed Build
- Steeplechase
- Walker

Order of Events

(May be modified by event organizers, note changes as listed by your event organizer)

- 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* may run in afternoon
- 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 <2024>

We will be awarding teams that can meet the Gold Standards set for different events! Each team member responsible for the entry is entitled to recognition.

Slope Climber: .....60 degrees

Delivery Mission: ..... 30 seconds **(corrected)**

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 in any trial

Steeplechase:..... 20 seconds **(corrected)**

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. We could all get old 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. If you feel a floor needs cleaning, please ask for that before your robot runs.

From the desk of

Tom Bickford

National Director, Robot Track Meet Association
Director, University of Southern Maine STEM Outreach & Services

Volunteers

- The robot track meets are offered by local organizations that organize and run the programs. These groups depend on coaches and parents to volunteer on the day of the event to assist as timers and officials. Some events may already have volunteers recruited but expect to lend a hand with a stopwatch or a clip board.

- 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, there will be 2nd and possibly 3rd place awards as well.
- Trophies will be determined by the number of teams pre-registered for the track meet and by the meet organizers.
- The overall winning team for the meet will be the one with the most points (Maximum possible overall score is 70 points: *7 events x 10 pts = 70 pts*)
    - 10 points for first place
    - 8 points for second place
    - 6 points for third place
    - 4 points for fourth place
    - 2 points for fifth place
    - 1 point for sixth place
- In the case of less than six entries in a meet event; points will be awarded from 1st place down to the number of qualifying entrants.
- 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, on down).
- Depending on the event organizers, all participants may also receive an event T-shirt. For example, in Maine all participants receive a 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) Events being entered, number of robots, NXT/EV3/Spike Prime/VEX® IQ type
   e) Names of all team members **and t-shirt sizes** (if provided by your tournament organizer)
   f) Release forms for all team members AND coaches (may be turned in before the event or at the event but must be returned prior to competing.

2) The 2024 registration costs are as follows:
   a) Early Registration, per team member, on or before 4/5/2024 ..... $45
   b) Regular Registration, per team member, after 4/5/2024 ..... $55
   c) Coach t-shirts (Youth Small through XL) $15
   d) Coach t-shirts (2XL, 3XL) $17

3) Shirts are included in all early registrations and MAY be included in regular registrations if we have enough (so register early). This is just based on when we have to place our t-shirt order.

4) Registration type (early or regular) is determined by the date you pay or provide a purchase order for payment.

Please see www.robottrackmeets.org website for additional information.

Section 2: 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 event registrations that does not exceed 7 registrations per team.

2) Team Composition
   a) No student may be on more than one team.
   b) A team is not limited in size.
   c) All members of the teams must be currently enrolled in grades 3 to 8, including home-school or alternative school settings for the spring of the 2023-2024 school year.
   d) All members must have a signed consent and release form to participate in the track meet.
   e) 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 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, teamwork, 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 a 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
2 fastest built robot, 2 bridges, 2 slope climbers, and a walker

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 by a team may result in scheduling conflicts at the meet.

While we attempt to accommodate scheduling conflicts, 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 morning events (either directly or through shared controllers).

Avoid sharing parts/controllers between the following:

- **Fastest/Strongest/Slope climber**
- **Steeplechase/Delivery/Table Clearing/Strongest**

If a team member was crucial to building and programming two different entries that run at the same time, they can designate a surrogate (substitute) to run their robot for them.

If you have a lot of robots or entries; 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 for the meet champion awards.

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® GO or 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 unless specifically allowed in event rules. When in doubt, build a better robot, not a better gizmo. Except for the Ping Pong Shot Put in which case the ping pong balls must, by the nature of the event, leave the robot; and the remote-controlled robot (if offered), which is, by definition, remotely controlled.
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 if they can satisfy the ownership requirements (demonstrate they built/programmed the robot)
    a. Robot controllers (brains) may be swapped between teams and team groups as needed to power different robots. So a robot controller could be used for the fastest in the morning and the ping pong shot put in the afternoon.
4. Check specific events for allowable arms, parts, and strategies.
5. <u>Event specific rules supersede these general rules</u>.
6. Equipment:
    1. A **Robot Controller** shall mean any of the following: A LEGO® RCX, NXT, EV3 or Spike Prime controller, VEX® GO Brain, or a VEX® IQ Brain.
    2. Each robot must include a robot controller (the onboard controller, not a remote control).
    a. Each robot may contain only a single robot controller.
        1. Additional robot controllers may not be used for ballast, regardless of whether they are electronically connected.
    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® robots may only have VEX® GO or IQ parts, no metal VEX® EXP or V5 parts **<NEW>**.
7. 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 a 30-degree slope. A robot capable of pulling 40 pounds must also be able to pull the 10 pounds.
8. 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.

c. Wires are expected to start behind the start line

9. 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. LEGO® or VEX® rechargeable battery packs are allowed as the power supply for the control unit.
    e. No power may be supplied from LEGO® or other wind up, pull back, elastic or spring powered devices. All power must be from the allowed motors and on-board power supply from the robot controller.
10. LEGO® or VEX® weights are allowed
11. Communications during competition:
    a. No communication is allowed between the team and the robot during competition
        a. If a remote-control event is offered, see individual event rules
    b. No IR Tower, Bluetooth, or Wi-Fi communication
    c. No robot controller to robot controller communication is allowed
    d. No Remote control devices of **any type**, wired or wireless
12. 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 usage.
13. Trials:
    1. In events that have multiple trials, robots will be removed from the arena between trials. With the exception that Ping Pong Shot Put trials are run in sequence due to setup time and potential damage to robots during transport.
14. 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 below). 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.

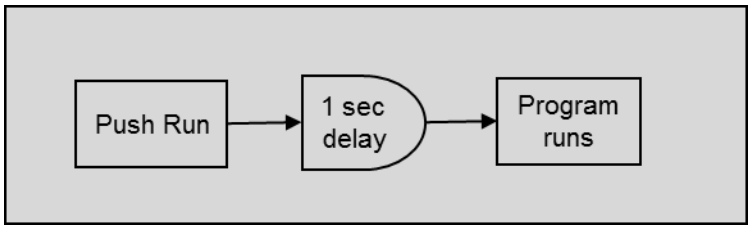


Figure 1 - Start Program Requirements

15. Robot Absence:
    a) If a robot/team fails to be present when called, the officials may move to the next contestant. If the round is completed without the team/robot showing, they will receive an INC (incomplete) for that trial/round. It may NOT be made up later.
    b) The officials and volunteers have no obligation to find teams or their members. However, attempts will be made to announce missing teams before the end of rounds within

individual events. The responsibility for being at your event in a timely manner is entirely with the team.

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 500,000,000 pieces of LEGO® for sale from other LEGO® enthusiasts like you! Suggest you limit your search to US to make it easier.
- And remember, if you aren't having fun, then you and your team are missing out!
- If a student is entered into an event, make sure they have read the rules for that event. While it is great if a coach can be the ultimate source of expertise, we find most children, who have a personal stake in the program, will pay attention to the rules that apply to their event.
- Rules for an event include BOTH the general rules AND the event specific rules.

Terminology

Meet: Refers to the entire day's activities

Event: Refers to each of the 10 different activities held at the meet

Entry: Refers to one robot, speed build, or bridge entered into one event

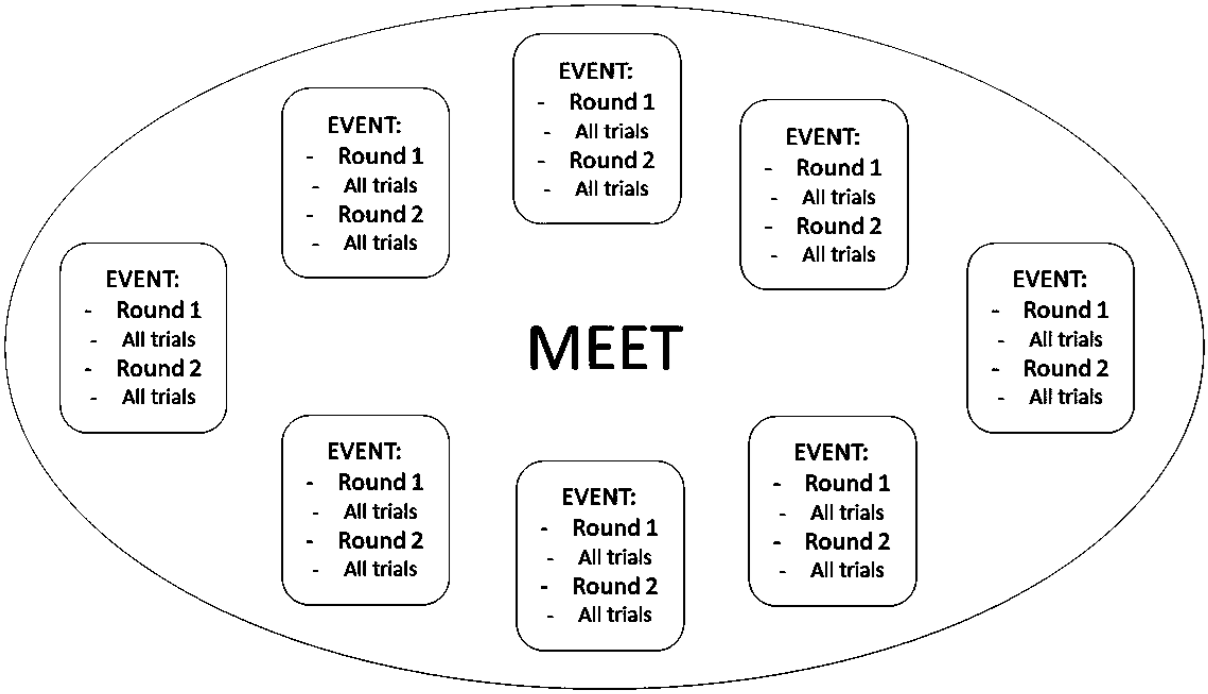
Trial: Refers to a robot or persons official run within each event, there may be more than one trial depending on the event.

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

Round: All trials within an event, different events may have 1, 2, or 3 rounds.

All first trials = Round 1
All second trials = Round 2
All third trials = Round 3

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


MEET
EVENT:
- Round 1
- All trials
- Round 2
- All trials
EVENT:
- Round 1
- All trials
- Round 2
- All trials
EVENT:
- Round 1
- All trials
- Round 2
- All trials
EVENT:
- Round 1
- All trials
- Round 2
- All trials
EVENT:
- Round 1
- All trials
- Round 2
- All trials
EVENT:
- Round 1
- All trials
- Round 2
- All trials
EVENT:
- Round 1
- All trials
- Round 2
- All trials
EVENT:
- Round 1
- All trials
- Round 2
- All trials

SECTION 3: EVENTS

In this Rule Book, each event is outlined in two sections:

1) The event rules, marked as RULES SECTION

2) The building and operating rules and guidelines, marked as BUILDING SECTION

For 2024, these are found together in each Event description.

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 or available on many smart phones as an app (See Figure 8).

c) Attempts:
   i) Each robot will have a total of two (2) attempts to complete a particular degree slope.
   ii) Completing the climb is a successful attempt and *automatically completes* the attempt at that slope. **No additional attempts are allowed.**
   iii) Failing to complete the climb at all attempts at a particular degree slope will end the robot's competition
   iv) Completed attempts will be marked with the time, in seconds (ss.0, one decimal place) of the climb.
   v) Incomplete attempts will be marked INC
d) Timing/Scoring:
   i) Each attempt may not exceed 60 seconds
   ii) Robot must reach the start line within 20 seconds of the team starting the robot
   iii) Score is equal to the highest slope successfully climbed by the robot
   iv) Time is the time from the robot crossing the start line to the time it crosses the finish line or is marked INC for an incomplete run.
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)
      (a) The start zone goes from knobs 0 to 36
      (b) The travel zone is from knobs 37 to 120 (84 knobs in length)
      (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 4, Figure 5, Figure 6, 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, except that the robot may touch the lower end wall of the slope.
   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
h) Plates:
   i) 6 knob x 12 knob plates (part #3028) can be purchased from Bricklink.com or other venues for $0.20-$0.30 apiece. You will need 44 of these, so you are looking at about $10 to purchase these plates. You can also cut down larger build plates (part #10400) which are 32x32 knobs and cost about $8 new or $5-6 each on Bricklink.com. You would need 5 of these to completely cover the surface. These plates are then glued down using some form

of contact cement. Note that LEGOs are made from ABS plastic and the glue should be suitable for use with this form of plastic (not melt it).

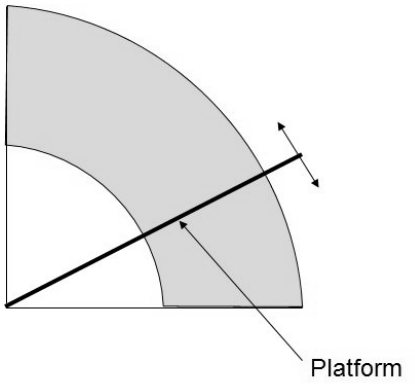


Figure 2 - Diagram of slope platform movement

ii) If using large building plates, connect the pieces together with bricks or plates to assure appropriate spacing before gluing.

iii) Also, if you are building from scratch, use 16 of one-color plate for the start and finish zones and a different color for the raceway. This makes it much easier to tell when the robot crosses these lines.

Event 1: Slope Climber Building Rules and Instructions

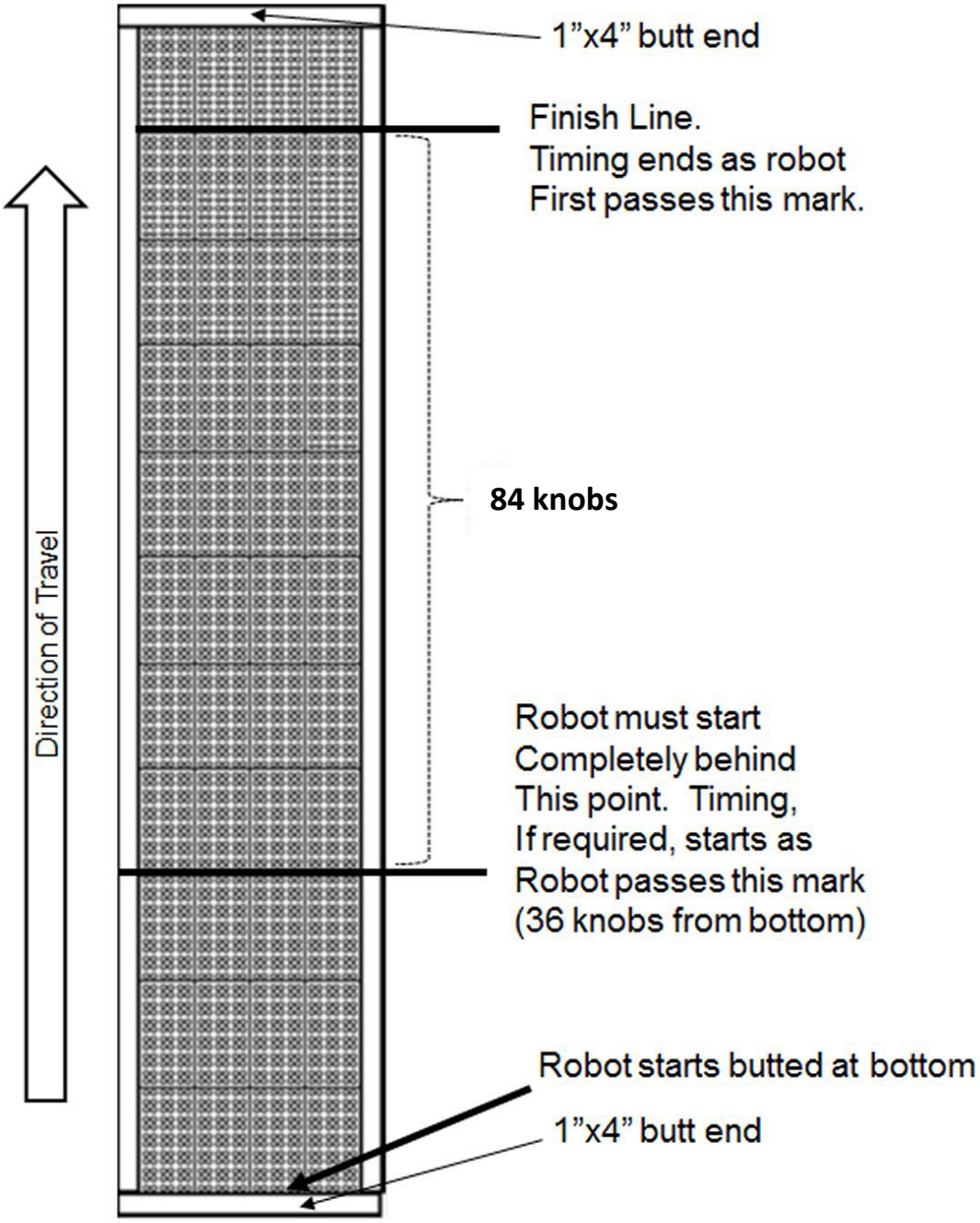


Figure 3 - Diagram of slope construction and slope zones

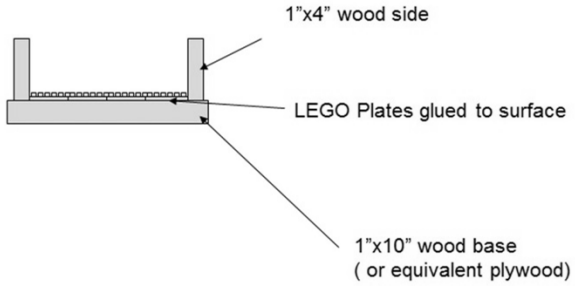


Figure 4 - Cross section of slope platform

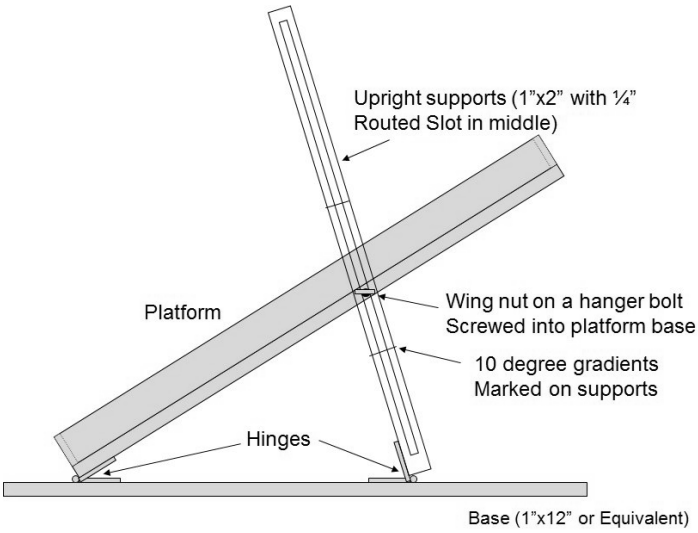


Figure 5 - Slope Climbing Assembly - side view

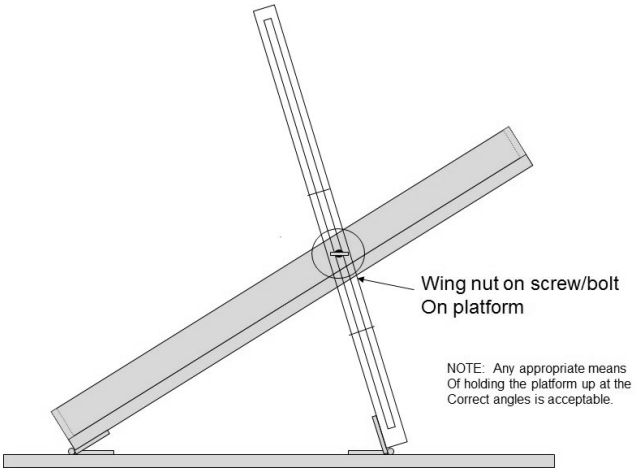


Figure 6 - Slope Climbing diagram showing location of alternative bolt location

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

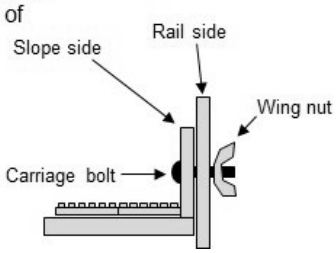
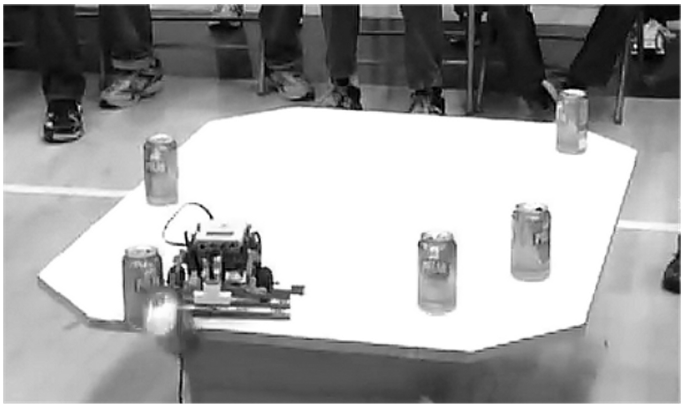


Figure 7 - Bolt system for alternative

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

Event 2: Table Clearing Mission



- Robot must navigate a tabletop 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 (empty and rinsed)
  - Cans may be unaltered or painted with flat-black spray paint.
  - 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
  - Sensors can be used to sense the edge of the table or the cans or both
  - Robots that rely only on dead reckoning will not be qualified to perform in this event
  - A sensor that is only used to start the program or trial does not meet this requirement
  - 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.
    - Use of gyroscopic sensors will not count towards this requirement. You can use them, but they do not meet the requirements of sensor incorporation
  - This event assumes that since the robot uses sensors that slight differences in table size does not count as a problem
    - Up to a 1” tolerance from specifications is allowed
- 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 must end)
  - Any moving parts must not exceed the total 12” x 12” maximum size allowance AT ANY TIME (so no rotor blades that fit while still but are larger than 12” x 12” when running.
- 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 goes to the greatest number of cans removed in one trial.
    - If a tie exists as to the number of cans removed in one trial, 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 (stop timer, count cans):
    - The 8th can is removed from the table surface
    - If the robot is touched by a human or falls from the table during its trial
    - 90 seconds have passed
    - The team requests to stop the trial
- Penalties:
    - There are no penalties if the robot falls from the table, or if the robot is touched by a human or if the robot stops on its own before 90 seconds have passed. Falling or being touched ends the trial**.**
    - There is no penalty if the robot is still running at 90 seconds
- 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, and then think about how you will program to make that happen.

Event 2: Table Clearing Mission Building Rules and Instructions

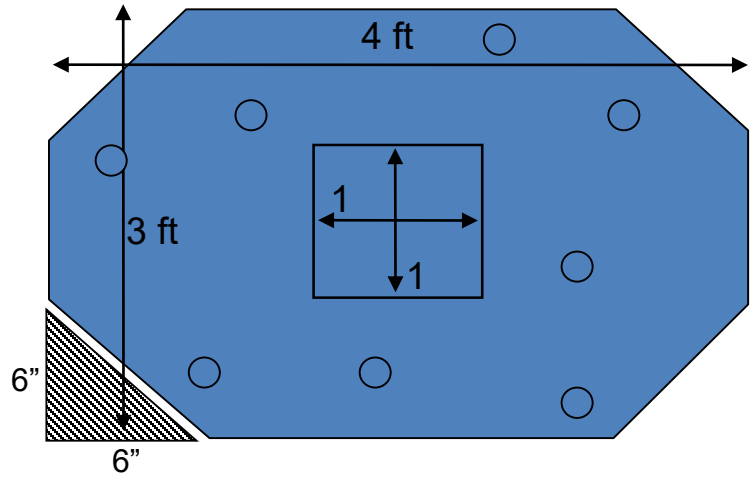


Figure 9 - Table Clearing table

The Table:

- Table is a 48 inches long and 36 inches wide equiangular octagon (122 cm x 92 cm)
- Tabletop 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.
- Table construction may be made any way to meet the requirements.
    - A smooth white gloss surface is required
        - White melamine cut to dimension or
        - Sanded plywood painted with several layers of glossy white finish
- There are no borders or markings on the tabletop except for
    - The middle square will be measured to be a 1-foot (30.5 cm) square, perpendicular to the sides and equidistant from the two sides and top/bottom respectively (1 ½ feet from each side, and 1-foot from the top and bottom).
        - The square shall be made by using a light colored (yellow or light green) fine tipped permanent marker.

Table Placement:

- A boundary around the table should be maintained that is free of obstruction to prevent sensors from “seeing” people, chairs, or other obstacles
- Table should be at least 12” above the floor to allow downward facing sensors the ability to differentiate the tabletop from the floor.
- Table should not be over 18” high to prevent excessive damage should a robot fall from the table.
- For practice, a team may wish to use small blocks of wood to keep off the floor, but competitions will place the table on constructs to be within the allowable heights.

Event 3: Delivery Mission

This event is designed for both building and programming skills!

1) Rules:
   a) Course
      i) The course is laid out in a 72" x 48" field **<NEW 2024>**.
         (1) Starting in 2024, we will be using printed vinyl mats. Teams may recreate this on a floor, back of a FIRST LEGO® League mat, on a piece of plywood, or on a floor surface.
      ii) One black line (3/4" wide) is provided as shown for those wishing to use a line follower leading to the **Drop Zone**
      iii) Four (4) ¾" x ¾" x 11.25" pieces of wood make up the boundary of the drop zone. One side of this boundary will have blue painter's tape to allow for sensors.
      iv) A ¾" blue line is used as a boundary for the finish line
      v) Team uses one LEGO® Object for the delivery mission (See Figure 10).
   b) Robot must **carry** the LEGO® object and must
      i) Deliver it into the Drop Zone.
         (1) The object must be touching the inside floor of the drop zone
         (2) The object may also be touching the walls of the drop zone
         (3) The object must not be touching either the outside of the drop zone or the robot
      ii) The team may **load the object** prior to the start of the run. The robot does **NOT** need to pick up the object.
      iii) The robot MAY use string[1] for the purpose of operating a lifting mechanism for object delivery. String may not be used to propel the object in any way.
   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, this is subject to the official's best guess.
   d) Qualification:
      i) Object is **carried** by robot to target
      ii) Object is dropped into the Drop Zone
      iii) The robot is no longer touching the object at the end of the mission
      iv) Dividers are in their original position
         (1) Dividers have not been displaced from their starting position by more than ½"
         (2) Dividers have not been knocked over
      v) Robot remains on the playing area
         (1) "Remains on" = all drive wheels/treads are in contact with the playing field at all times.
      vi) Robot crosses the finish line
      vii) Robot completes objectives in less than 30 seconds **<New 2024>**
   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 crossing the finish line, with delivery occurring between these two times.
      iii) Ranking will be based solely on time to successfully complete this mission

Event 3: Delivery Mission Building Rules and Instructions

[1] May be any form of string.

3) The delivery mission may be laid out on a sheet of plywood, a 48” wide mat of paper or vinyl. **Starting in 2024 we will be providing a PDF version of the mat for any teams that wish to have a paper or vinyl mat printed (optional) <NEW 2024>**. See Figure 10.

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
      iii) Each divider is 12” long, 6.25” tall and 1.5” wide at its base
      iv) Painted flat black and fastened with appropriate screws (between base and wall)

5) Drop Zone
   a) The drop zone walls are made from ¾” x ¾” x 11¼” pieces of wood. This results in a 12” x 12” outside dimension box with ¾” x ¾” walls. Inside dimension would be 10½” x 10½” space.
   b) NOTE: for stability purposes, a ¼” piece of plywood may be used to construct this as a single piece and used as the base. This would require changing the dimensions of the walls to be only ½” tall so the TOTAL height from floor to top of the Drop Zone remains ¾”. This reduces the inside dimension depth to ½” as well. Do not use any material that is thicker than ¼”.

6) 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

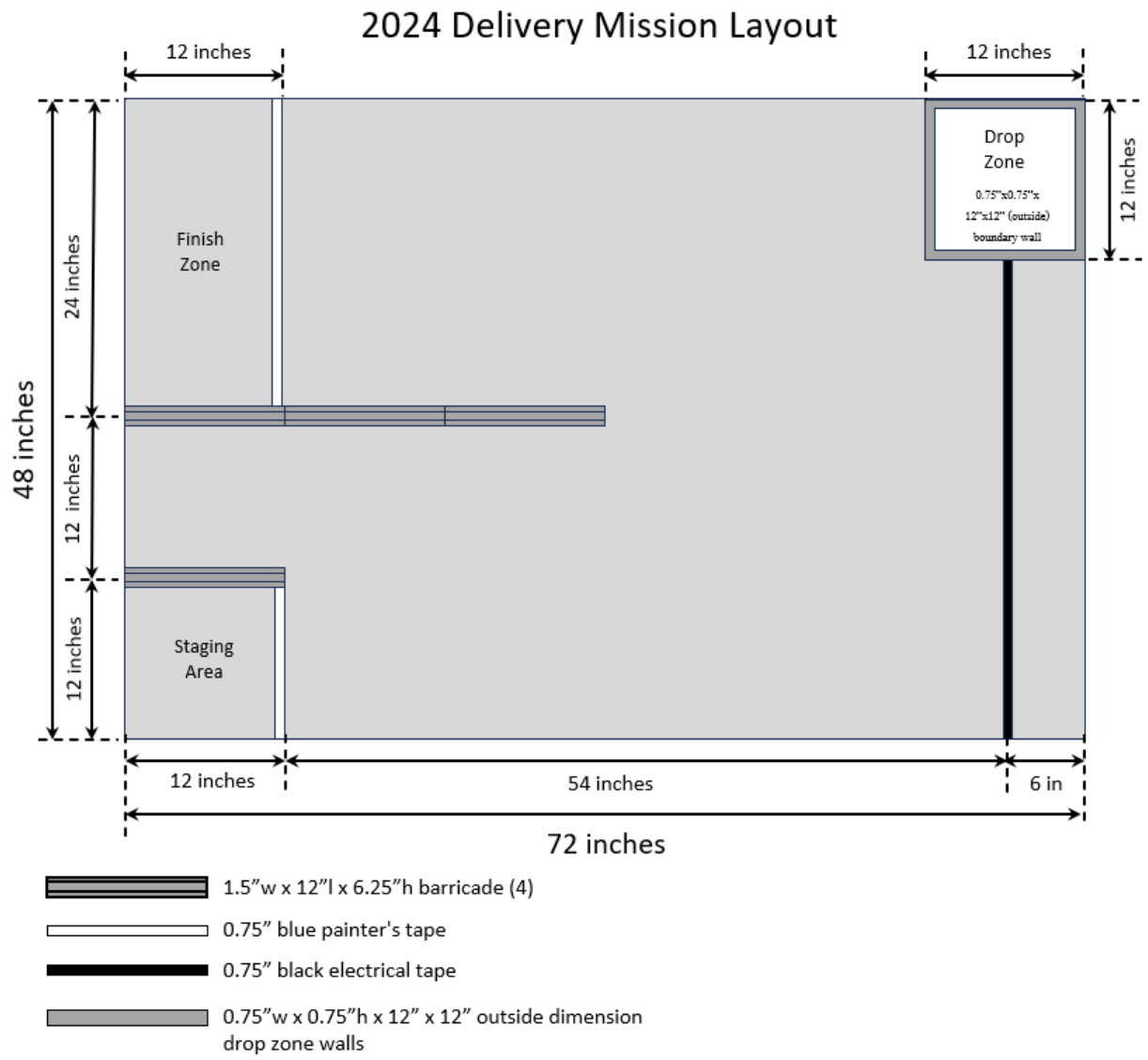


Figure 10 - Delivery Mission layout

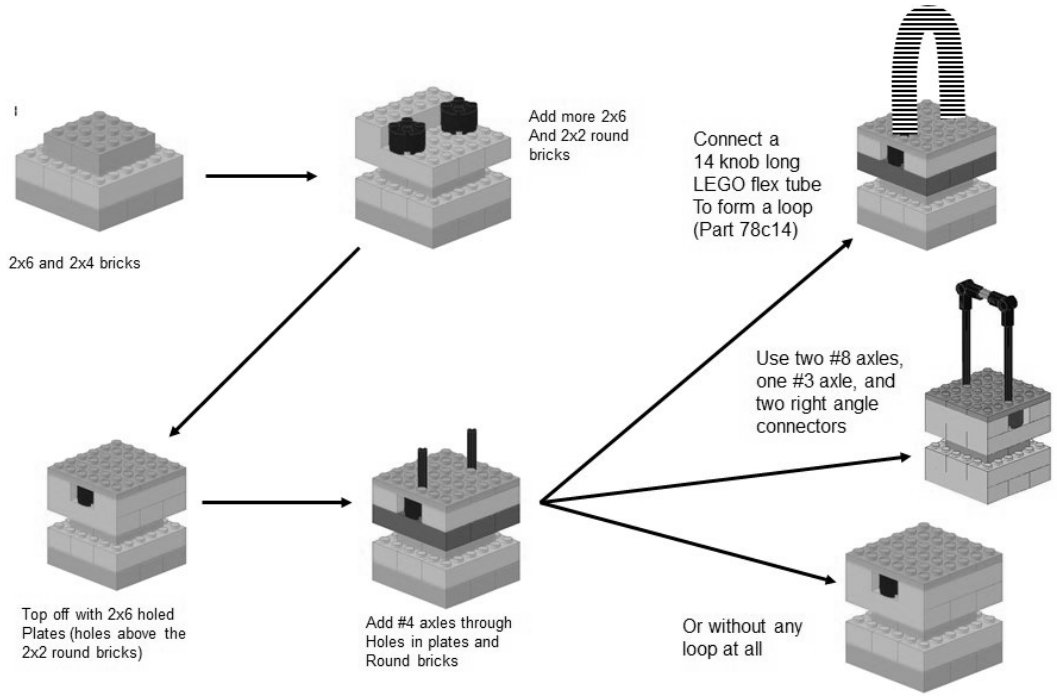


Figure 11 Delivery Mission Object

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 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, **18 feet** away from the finish line, and centered with the starting 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. See Figure 13 and Figure 14.

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) Visit www.robottrackmeets.org and go to "downloads" and "laser light trigger" for building the light sensor trigger assembly and some simple programming directions

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)

ii) Robot must complete the course in less than 30 seconds **<NEW 2024>**

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 stopwatch is good for practice.

5) Ties:

a) If a tie occurs, then the 2nd place best time will be used

b) If a tie still occurs, then the best average of 3 trials will be used to break ties

Resources:

6) http://science.howstuffworks.com/fpte.htm is a good site to learn more, although they have more ads each year.

Event 4: Fastest Robot Building Rules and Instructions

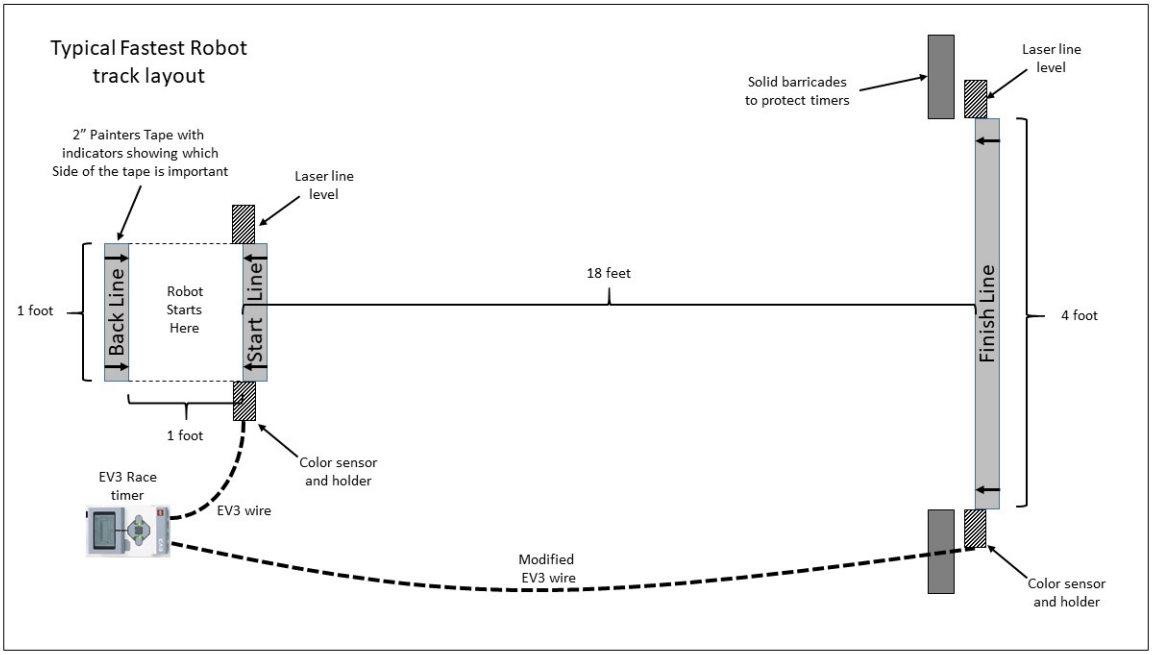


Figure 12 - Fastest Robot course layout

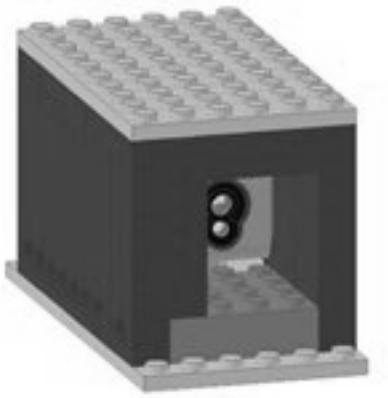


Figure 13 - Laser light sensor construction

Figure 14 - Laser Line Level

BUILDING SECTION

1. The course is laid out on a flat, non-carpeted surface. If hardwood, as found in many gyms, run with the wood, not across it in order to minimize the bumps. You may also want to use naturally occurring lines, such as sport arena lines, for the starting line.
2. The course is 18' (5.5 m) from the Start line to the Finish line.
    a. Make sure that whatever lines you use to mark the Start and Finish Line that the edge to be used is clearly marked. Use a permanent marker on the tape to draw lines to the appropriate edge.
    b. A Back Line is 12" (30.5 cm) behind the start line and delineates the starting area for a robot.
    c. The Start Line is exactly 12" (30.5 cm) from one side to the other and can be delineated using pylons or the Laser Light assemblies.
    d. The Finish Line is exactly 48" (122 cm) from one side to the other and can be delineated using pylons or the Laser Light assemblies.
3. No other restrictions are placed on the field, either physically or by rule.
4. NOTE: For the Laser Light assemblies to work, you need to modify a single LEGO® wire by cutting it and soldering in a long enough piece of 8 conductor wire. Cat5 or Cat6 cable works well. This allows for both light sensor assemblies to be attached to a single NXT or EV3 controller.
5. Directions for building and programming the Laser Light Assemblies can be found at www.robottrackmeets.org and checking on our Downloads page.
6. In competitions, it is HIGHLY recommended that you use a barrier system around the entire area, with an opening at the start end for teams to enter when called. Barriers can be made with chairs, rope, and spring clamps, or any other suitable material so as not to create a hazard to spectators or participants.

Event 5: Strongest Robot

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® parts to make the connection
         (3) MOST FAILURES OCCUR AT THE CONNECTION POINT, SPEND SOME TIME ON THIS BEFORE THE COMPETITION, (see Figure 16-17 for good examples of connections)
         (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. 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 8)

c) Trials:
i) Each robot shall have no more than TWO (2) trials at each weight limit to successfully cross the finish line
ii) Each robot successfully completing its first trial is done at that weight. No more attempts are allowed.
iii) 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, or failed to cross the start line, after 20 seconds
iv) Trials shall start at 20 pounds
(1) <NEW 2024> if needed, a single qualifying round with 15 pounds may be used to determine which robots may compete. Failure to pull 15 pounds will result in the robot being eliminated <u>prior</u> to the start of the competition.
v) Once a robot has successfully completed the course at a weight limit, the robot's time to complete is noted and the robot is finished at that weight limit.
vi) If a robot fails to successfully complete the course at a weight limit, the robot is marked INC
vii) Two incompletes at a weight limit will eliminate the robot from the competition.
viii) The weight will increase at 5-pound increments to **60 pounds** in an elimination competition.

d) Scoring:
i) The team that can pull the most weight, up to and including 6o pounds, 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.

e) Ballast:
i) Each robot may use as ballast any LEGO® or VEX® parts AND one or two 12 oz cans of DIET SODA in original and full condition (please use diet in case it spills is much easier to clean than sugared drinks)
ii) Ballast must be attached with only LEGO® or VEX® parts and must be on the robot and completely off the ground.
iii) Any LEGO® or VEX® pieces, including LEGO® weights may be used as ballast, except
(1) No electronics other than those allowed under general rules may be used, no extra robot controllers are allowed, even as ballast.
iv) Use of any ballast is completely optional.

BUILDING SECTION

Event 5: Strongest Robot Building Rules and Instructions

1. Setup on a floor without integral barriers within the floor design.
    a. Do not run on carpet
    b. Do not run across wood planking, but with the planks (as found on most gym floors)
    c. Do not run tape across for either the back line or the start line, but rather use a natural line on the floor, such as a sport boundary line or a vinyl tile line for the start line. The back line can be marked on the sides and if needed a straight edge placed across if there are questions about the overall length of the robot.
        i. This is to prevent obstructions that the robot cannot overcome under a weighted load. Even tape on the floor can be an issue.
    d. The finish line can be a line of tape. Since the robot does not need to drive across this line, it only has to reach it, there is no issue impeding the forward progress of the robot.
    e. Look out for turned up corners of tiles and/or wood planks. Also, for dips that could trap a wheel.
2. There are no barriers or barricades used.
3. The Start Line
    a. The start line is 24" (61 cm) wide.
    b. The robot must be completely within the boundary between the back line and the starting line.
4. The back line
    a. The back line is 24" (61 cm) wide.
    b. The back line is only marked at the sides. No tape should cross the path of the weight cart.
    c. The back line is 12" from the start line.
5. The Finish Line
    a. Is 24" (61 cm) wide and 24" (61 cm) from the start line
6. Cart:
    a. The wagon must be at least 11" (29 cm) wide and 16" (40 cm) long
    b. The front face shall have a 3/4" piece of wood attached to use for the attachment of the one U bolt **<NEW MODIFIED 2024>**.
    c. The wagon will have **one solid loop** 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 loop will be centered on the front of the wagon. We use 1-5/8" diameter, ¼" thick U bolts (available at hardware stores). (See Figure 16).
    d. What a team uses for a wagon is immaterial except that an equivalent loop be provided at the same height for practice
    e. 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 and bearing wheels shall not be used.

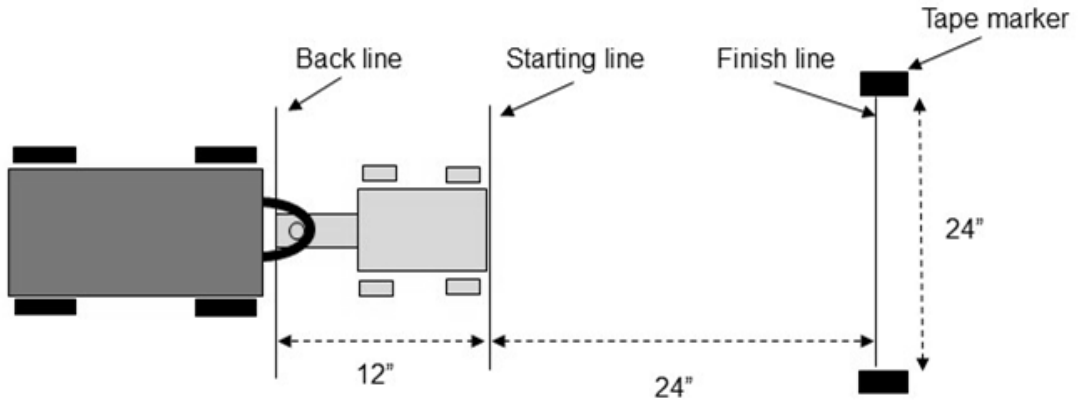


Figure 15 - Strongest robot course - overhead view

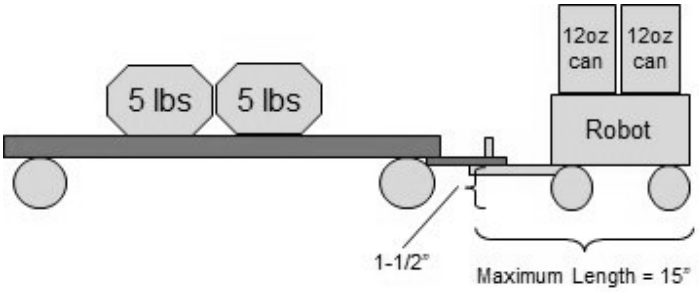


Figure 16 - Robot and Cart configuration - side view

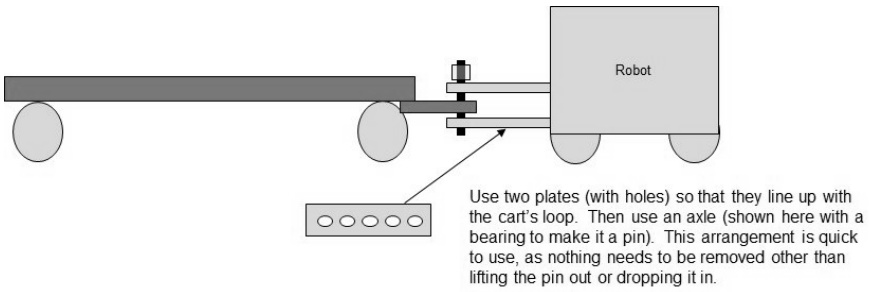


Figure 17 - Possible robot-cart connection

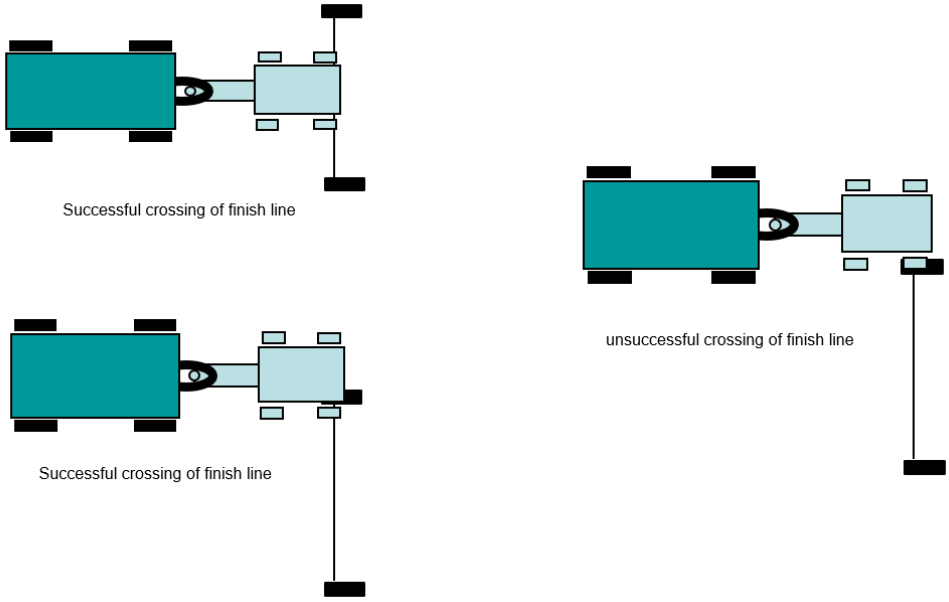
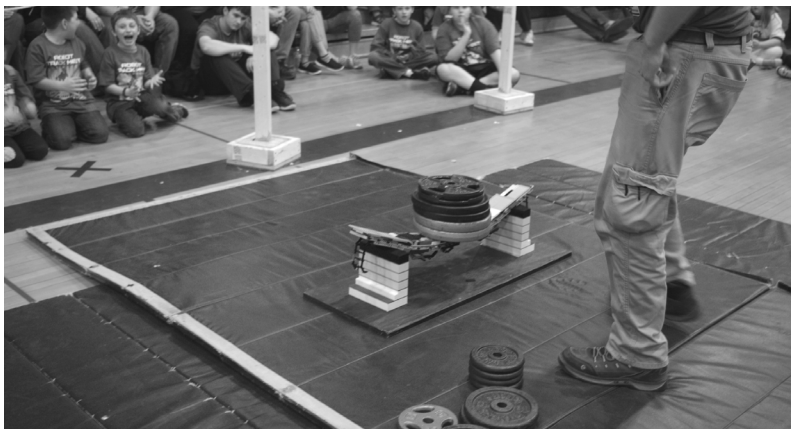


Figure 18 - Crossing the finish line

Event 6: Bridge



1) Background:
   a) In the Bridge event, teams bring **pre-built** LEGO® bridges to the competition. Each year several bridges tested have held up to 200 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 1819, Figure 20, Figure 2121, Figure 1922, Figure 2023, and Figure 24)
   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, or 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) 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 official weight for the event.
   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 RTMA 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/buttresses) 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 Figure 22, and Figure 2123)
   c) The top of the support structures is 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 1922, and Figure 2023).
   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 the event coordinator. 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.
   j) The supports must be free standing and in no way attached to the base surface.

4) Safety:
   a) All weight loading is done by the event organizer and may not be done by any minor.
   b) Steel toed shoes or boots as well as safety glasses are required by anyone loading the bridges.
   c) All team members and audience members must be a minimum of 8’ from the bridge during loading
5) Bridge Check-in and preliminary test
   a) Each bridge will be weighed, and the length measured at the beginning of the competition
      (1) There is no weight limit to the bridges
      (2) **<NEW 2024> if needed, a single qualifying test with 10 pounds may be used to determine which bridges may compete. Failure to withstand 10 pounds will result in the bridge being eliminated <u>prior</u> to the start of the competition.**
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
      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. Tensile stress is the amount of force, and 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 the 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

Event 6: Bridge Building Rules and Instructions

Basic layout on floor:

1) Gym Mat to protect floor
   a) A large gym tumbling mat of at least two inches thickness would be suitable.
      i) Mats that are too thick make it difficult to support the loader (person) while not disturbing the bridge assembly
      ii) Mats should extend at least two feet out on all sides of the plywood. Use more mats if needed
2) Plywood to support the bridge supports, bridge and weights
   a) Outlines of the bridge supports marked on the plywood to allow for easy placement between bridge attempts
   b) Basic plywood should be approximately 36" (90 cm) long by 12" (30 cm) wide and at least 5/8" (16 mm) thick, but variations larger than that are fully permissible as long as they are safe. NOTE: if the plywood is too wide, it is difficult to load the bridge without stepping on the plywood, which is inherently unstable while on the mat.
3) Bridge Supports (see Figure 1819, and Figure 0)
   a) 6 knobs (LEGO) by 24 knobs wide by 20 bricks tall
   b) May exceed the 6 knobs dimension as long as any excess is away from the center span area
   c) Top 2 bricks of the supports must be 6 knobs by 24 knobs
4) Weights
   a) Metal gym weights (dumbbells) are easiest to use. The competition is only 80 pounds, but you may want additional weight so you can do destructive testing of the bridges. Listed below, a total of 175 pounds of weight. But whatever works and isn't messy to clean up.
   b) Four (4) 25 pounds weights
   c) Five (5) 10 pounds weights
   d) Five (5) 5 pounds weights

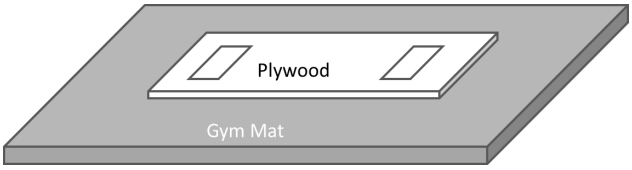


Figure 19 - Bridge setup and layout

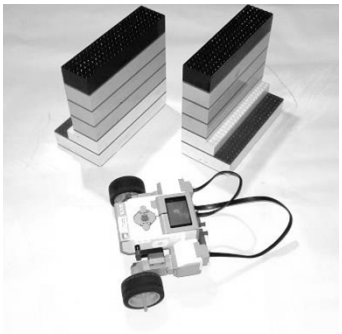


Figure 20 - Bridge supports (robot for size comparison)

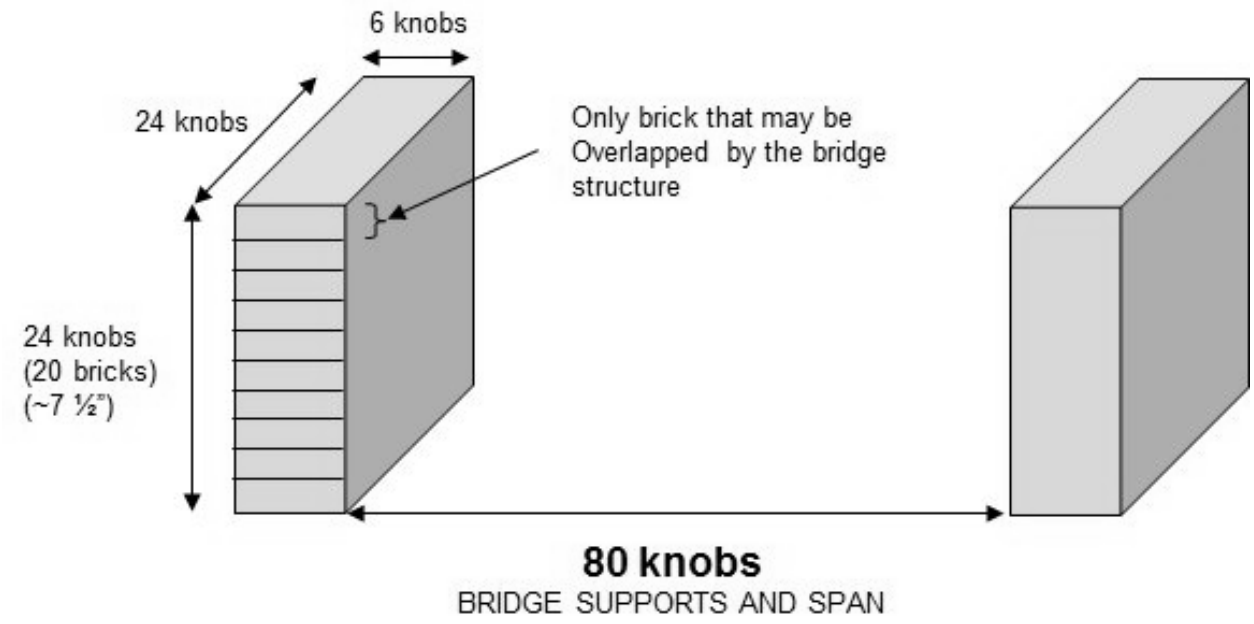
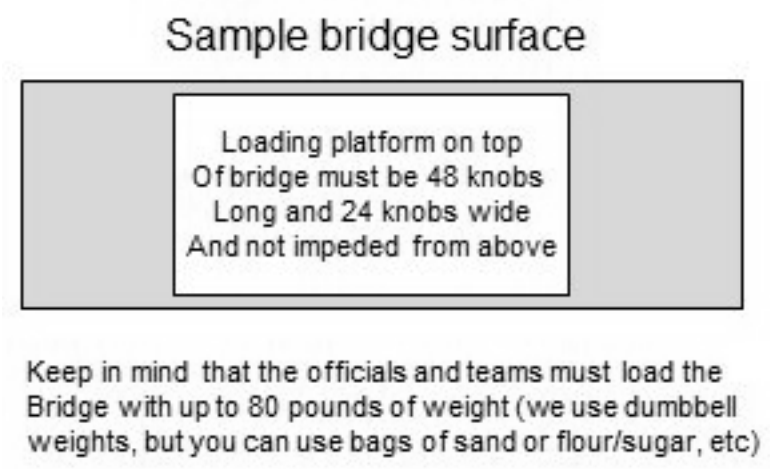


Figure 21 - Bridge support and span dimensions



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 22 - Bridge loading platform (on top of bridge)

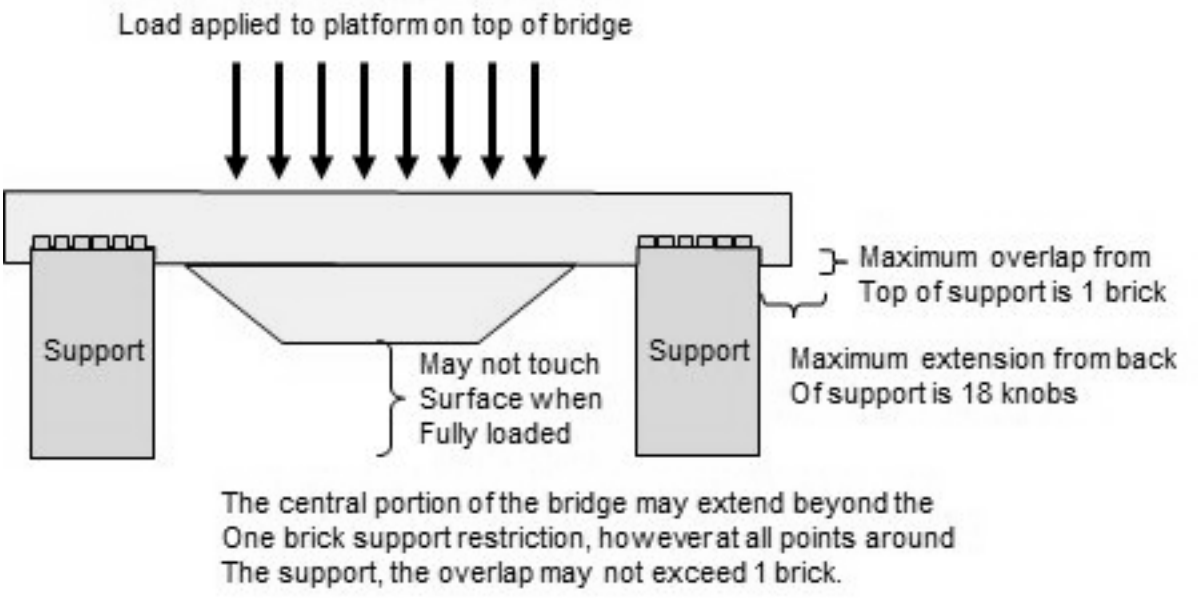
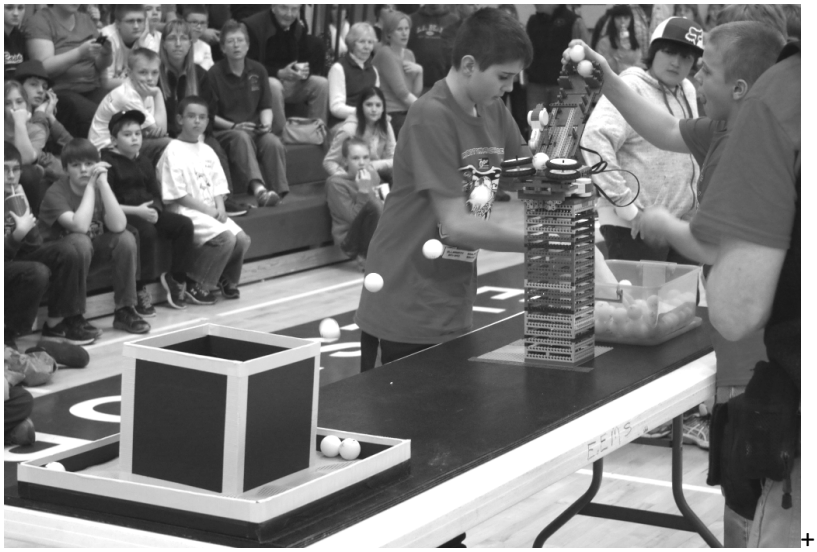


Figure 23 - Bridge attachment and layout

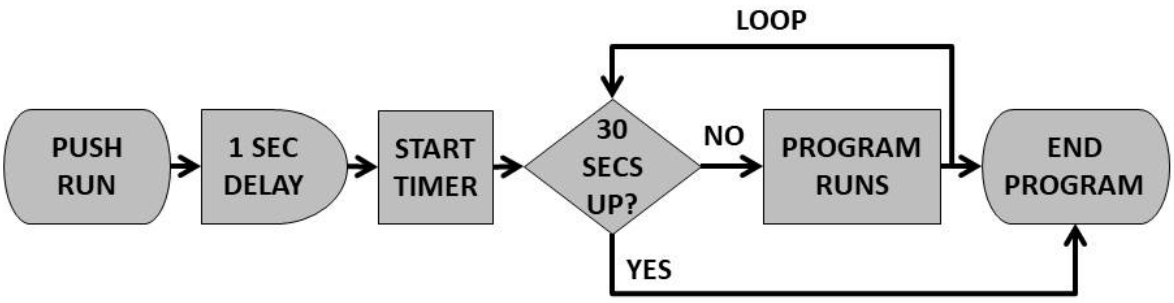
Figure 24 - Showing bridge, stanchions, plywood, gym pad and weights

Event 7: Ping Pong Shot Put



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) The program MUST be time limited to run for 30 seconds and then stop.
         (1) Prior to official runs, the team will demonstrate the 30 second time limited program.
      iv) Teams will start the trials by hitting the run button, or by triggering the program by means of an attached sensor.
         (1) The trial must then have a 1 second delay before the robot physically moves
         (2) The trial will run for exactly 30 seconds
         (3) After 30 seconds, the program must cease all operations



v) After the trial, the score will be the number of ping pong balls in the receiving boxes.
vi) Any balls actuated during the robot's 30-second trial will be allowed to complete their transit prior to scoring.

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 3-minute reset period between the trials
      (1) Officials will score each trial by counting the balls in the high/low goals with one of the team members confirming the count.
      (2) Reset period is to recover balls and re-aim the robot, team may test fire the robot.

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 may be located at any distance behind the start line, so long as it still sits on the plywood base.
   iii) The robot must sit on the event surface (cannot be placed on boxes, etc.)
   iv) The robot may not exceed 36" in height while at rest or transport.
   v) The robot may not exceed 24" in width or 30" in length **<NEW 2024>**
   vi) 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)
   vii) The robot may not touch the receiving boxes at any time
   viii) You may no longer use any tape to secure the robot to the table, however a piece of foam shelf liner will be available to prevent slippage of the robots during the trials.
   ix) 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 fed into/onto the launching mechanism OR to allow the launch of any auto-fed balls. The program must still cease all operations after 30 seconds.
   x) Loading the robot:
      (1) Ping pong balls may be loaded on the robot prior to starting a trial. 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 allowable to make replaceable ping pong magazines. Replacing these magazines would be the only time a team can touch the robot during its trial.
   xi) Delivery mechanism:
      (1) There is no limit on the mechanism of delivery, except as restricted in these rules, BUT the robot must use some internal mechanism to actuate the delivery process. Robots cannot be chutes that allow free flowing ping pong balls to flow from the hopper to the chute to drop on the playing surface and bounce to the goals.
      (2) No gravity fed delivery systems, even if actuated by a robotic gate.

(3) The robot must cease any active or reactive delivery mechanisms at 30 seconds into the trial.
(4) If a ball becomes "lost" it may be retrieved by the team and reused.
(5) The balls may be thrown, bounced, or shot into the receiving box

xii) For the purposes of the meet, you will be supplied with 30 ping pong balls for delivery. If you believe your robot can deliver more, please bring a supply with you for use at the meet. Use a marker to appropriately mark your table tennis/ping pong balls.

d) Human operator interference with the robot
   i) The team is allowed one (1) #15 Technic lift arm (or equivalent item in VEX) to prod clogged ping pong balls. Team members cannot touch the robot, but at times a simple push with a lift arm will open a clogged pathway.
   ii) No repairs may be made during a trial. If your robot falls apart; gears become unconnected; or your alignment comes out of true, you must stop or let the time run out on your current trial, and your score will be counted, and your trial completed.
e) 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

f) 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 years 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 three minutes to get setup, load, and zero in your robot, so practice this at home/school and make sure you can do that.

Event 7: Ping Pong Shot Put Building Rules and Instructions

a) The event setup (see Figure 25)
   i) We will be using a finished (sanded) plywood base that is 2 feet wide (60 cm), 8 feet long (2.4 m) and ½" thick (12.5 mm) 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.
   ii) The event may be run on the floor, this may be necessary for teams of shorter members. In such a case it will still be run on the plywood, just on the floor. This will be allowed only on a case-by-case basis.
   iii) The surface behind the start line will be covered in a foam coating to provide traction for your robot assembly. Use foam shelf liner.
      (1) ***No tape will be used*** as a result of this new method of preventing robot slipping.
   iv) **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) The floor inside the box will be lined with felt sheets (or equivalent), cut to fit.
      (5) Attached directly to floor or table
   v) **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.

b) 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.
   ii) Meet organizers will supply the trials with 30 ping pong balls for delivery. If after practice you believe your robot can deliver more, please bring a marked supply with you for use at the meet.

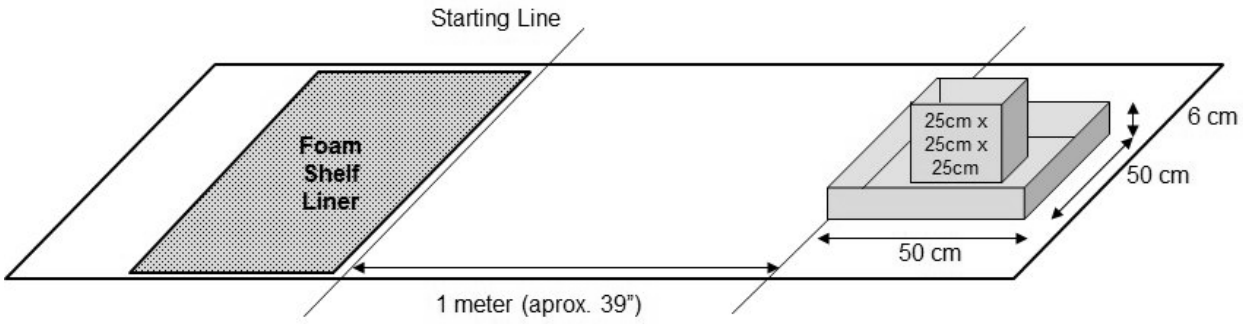
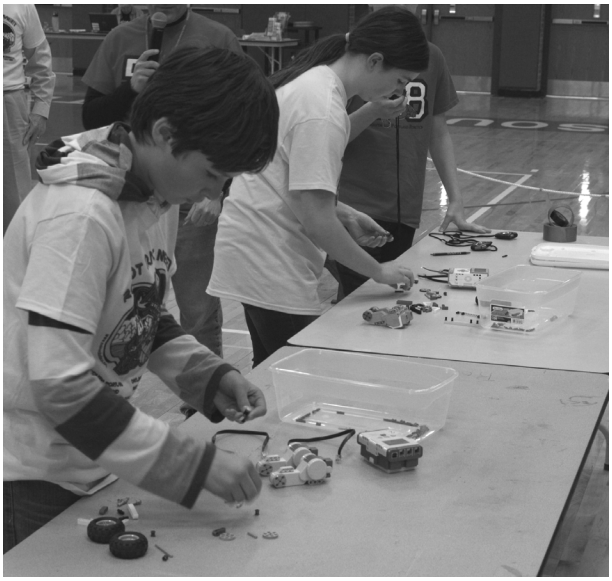


Figure 25 - Ping Pong Shot Put course layout

Event 8: Robot Speed Build



This event provides an 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, the Simple EV3 Robot, or the simple Spike Prime robot. Robot will be in a covered bin. **
   b) Note: a local event may have to limit this event to only one or two robot types due to availability of robots or may require teams to provide the robots. Check with your local event coordinator.
      i) Several extra bushings and black connectors will be in each container just in case some go missing or are dropped. True for either supplied or entrant provided robot.
      ii) Competitors must inform officials if there are parts missing PRIOR to the start of the trial, so check quickly.
   c) Each contestant builds the **Simple NXT, Simple EV3, or Simple Spike Prime Robot**

Directions for the robots can be found at www.robottrackmeets.org
(see Figure 26, Figure 27, and Figure 28)

   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 robot. Spike Prime robots will have the same program on all program slots.
      iii) We highly recommend that you use your setup time to turn on your robot's brain, so you do not 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 and in the container prior to the start of the round
   i) Setup Time:
      i) Contestants are given one minute to lay out their parts prior to the start of the round

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
   iii) Each contestant will disassemble their robot between trials and return the parts to the provided bin.

l) Scoring:
   i) A contestant's 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) ***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.
   b) ***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 will feel pretty bad when you get disqualified at the 6-minute buzzer.
   c) The world record is 1 minute and 54 seconds! Set in 2017, go Inez!

Figure 26 - NXT Simple Robot

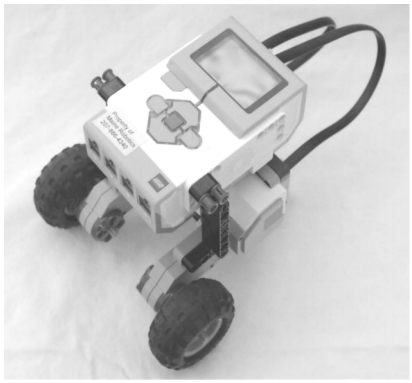


Figure 27 - EV3 Simple Robot

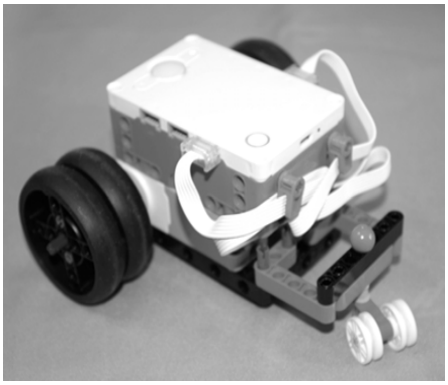


Figure 28 - Simple Spike Prime Robot

BUILDING SECTION

Event 8: Speed Build Rules and Instructions

No additional directions required.

The event is played on a table, with enough space for contestants to open the container of parts, spread them out, and then build the prescribed robot.

Timers are present for each contestant and start when the official starts the trial.

Timers finish when the contestant's robot clearly travels forward.

Event 9: Steeplechase

Steeplechases started as 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 or people race with standardized obstacles for the horse and rider or runner to navigate.

The robot 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, no pins or enclosures allowed.
   d) Time is measured from the crossing of the start line to the crossing of the finish line.
   e) Robot must complete the course in less than 60 seconds **<NEW 2024>**
   f) End of Trial:
      i) Completed:
         (1) Robot crosses the finish line with rider attached
      ii) Incomplete:
         (1) The robot leaves the course completely (usually falling off) before crossing the finish line
         (2) The robot partially leaves the course and cannot get back on (hangs on an edge)
         (3) The robot becomes stuck at a transition point (the pit or the peak usually) for more than a count of 10
         (4) **A human touches the robot**
         (5) Team "calls" the trial, there is no limit on when the team can call the trial
   g) Each robot has 3 trials to get 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) Spike Prime 57x14 drive wheels (tires part #39367)
      iv) VEX® IQ standard 100 mm or 200mm travel drive wheels (200 mm tire and hub #228-3505)
      v) Other LEGO® or VEX® IQ wheels with wheel diameter not to exceed 64 millimeters (2.5")
      vi) Wheel width is not restricted
      vii) Number of wheels is not restricted
   i) Treads allowed:
      i) No restrictions in 2023 for types or sizes of LEGO® or VEX® IQ treads, except where added to wheels such that you have a wheel with tread surrounding it and its modified diameter exceeds 64 millimeters.
2) Course: (see Figure 29, Figure 30, Figure 29, Figure 21, and Figure)
   a) A ¾" 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.

3) Scoring:
   a) Best time of three trials
      i) Winner is the robot with the fastest time in any one trial
   b) Ties:
      i) If two robots have the same time to cross finish line, then 2nd fastest time is used to select winner
      ii) If two robots have identical 1st and 2nd fastest times, then the third fastest time is used to select the winner

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 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 **the right** side of the course.
   g) Reaching the finish line.

Event 9: Steeplechase Building Rules and Instructions

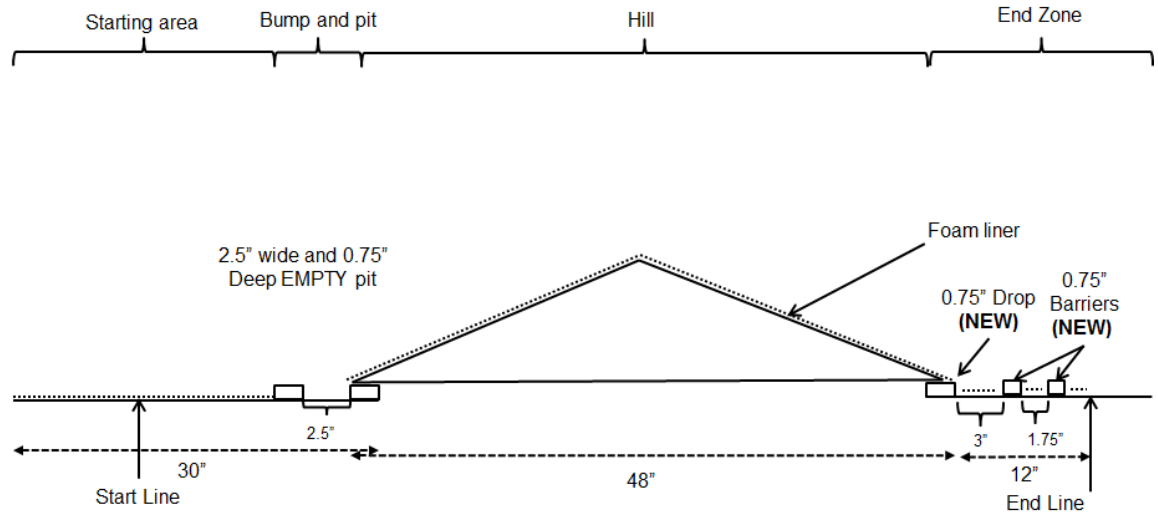


Figure 29 - Steeplechase course - side view

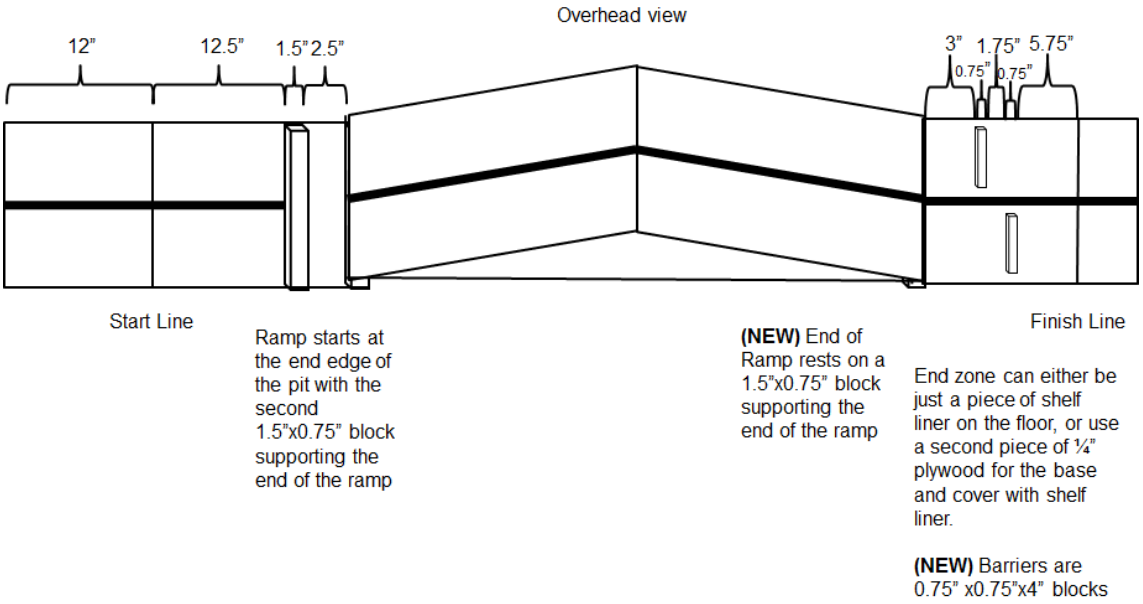


Figure 30 - Steeplechase course - overhead view

<New 2023> The Shelf Liner used at the competitions is Duck brand EasyLiner Select Grip White foam shelf liner. Available online or at stores near you. A roll of 12" x 20' EasyLiner is around $10. We use a spray adhesive to attach it to the wood surfaces, but the rules also allow for an edge of duct tape along the outer edges of the surface and wrapped under to hold the liner in place.

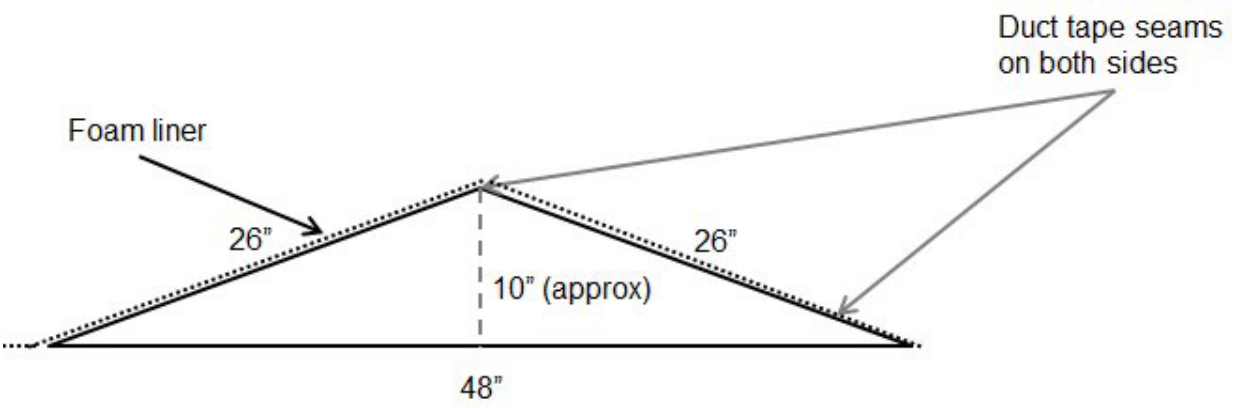


Figure 31 - Hill detail

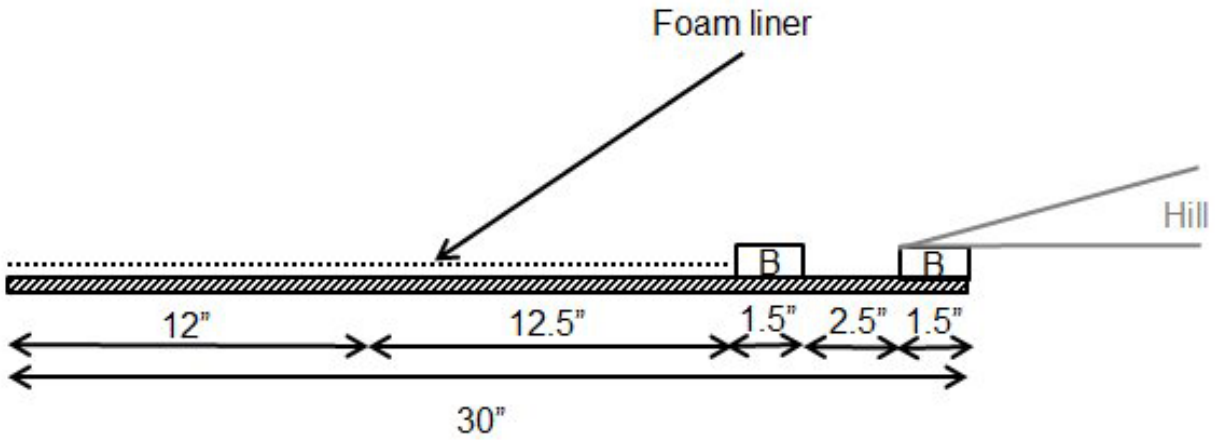
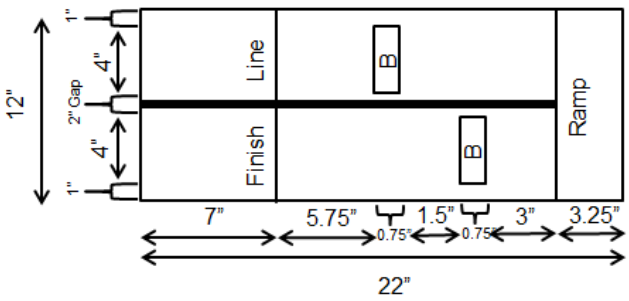


Figure 32 - Start and pit area detail



One 22" x 12", ¼" 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 33 - Finish line and barrier detail

Event 10: Walking Robot

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 34)
      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) Sidewalls WILL be used along the course take this into account! You do not want your robot to get stuck on the walls.
   b) Timing
      i) Fastest qualified time wins.
      ii) Time to transit the course is measured from the time the robot touches/crosses the "start line" to the moment it touches/crosses the "finish line."
   c) Robot
      i) Robot must have a one second pause at the beginning of the program
      ii) Entire robot (robot controller, motors, body, wires, etc.) must be one unit
      iii) Robots 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, for example a 6-legged robot may have 3 active feet and 3 immobile feet.
      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.

RULES SECTION

Walking Terminology:

- **Gait**
  The pattern of movement in limbed locomotion on solid surfaces (does not 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:
Visit the Robot Track Meet Association's Download Page and download the "Terminology of Human Gait" from the 1993 and 1994 NASG and AAOP conferences.

Biped, Triped, Quadruped, Hexapod, Octopod?? What form of design will you use?

https://www.youtube.com/watch?v=B_DLrNlQCo8 LEGO® Robot Dog (think Boston Dynamics)
https://www.youtube.com/watch?v=TRQBp0A9RSM Cool strider robot with building directions.
http://youtu.be/sAQS4NLEnEw Robot Granny monopod with a walker!
http://youtu.be/ImVQ2tmS1O8 8 legged robot that can turn
http://youtu.be/R1jARHRn8e4 another 8-legged robot
http://youtu.be/fa7IAvvYPOs 8-legged spider bot that can turn
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)

Event 10: Walking Robot Building Rules and Instructions

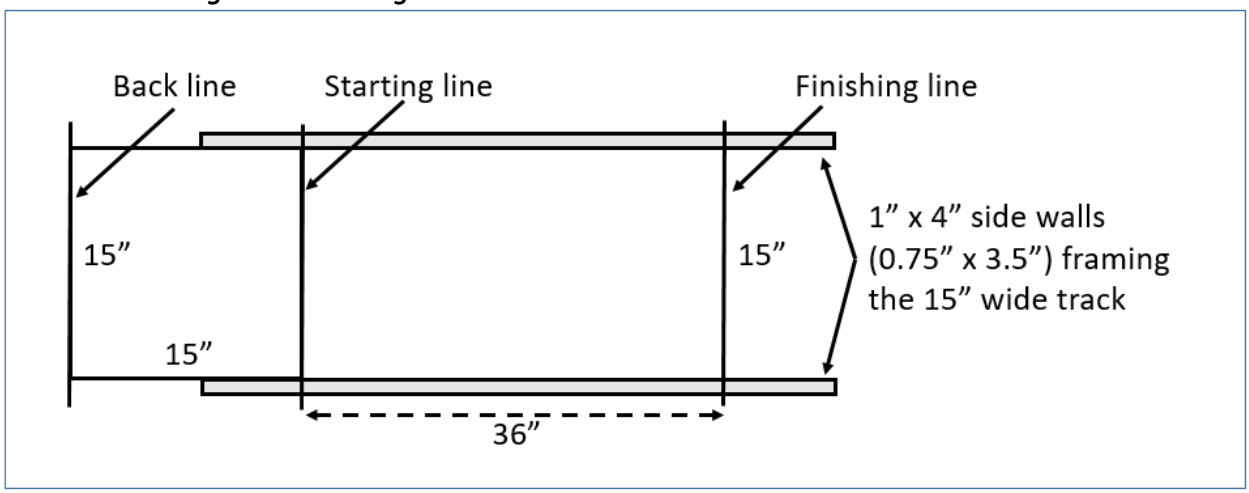
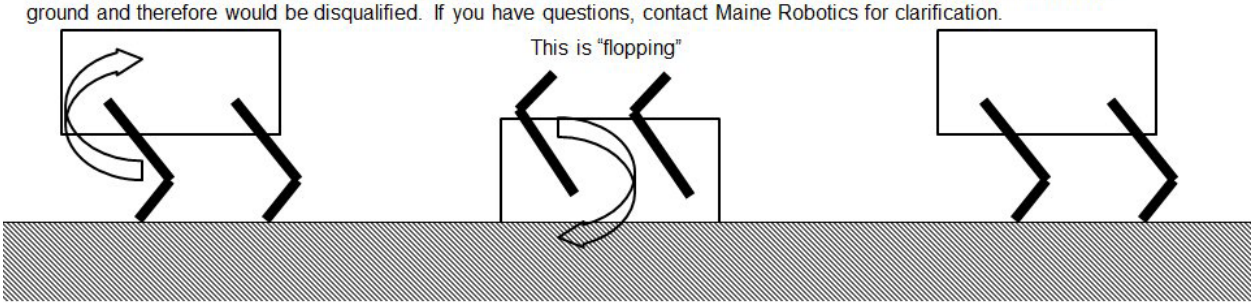
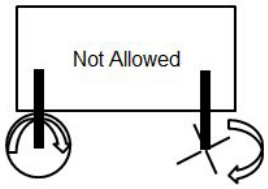


Figure 34 - Course diagram

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 35 - Flopping and Rotating Motions Not Allowed

INDEX