MAINE ROBOTICS

Our 11th Year!!

2015 Maine Robot Track Meet

Note changes from previous years

Sponsored by Maine Robotics

Director: Tom Bickford

www.mainerobotics.org/trackmeet.html

2015 Dates:

- *May 2nd, 2015* – South Portland High School
  - 637 Highland Avenue, South Portland, ME 04106
  - http://highschool.spsd.org/web/
- *May 9th, 2015* – Messalonskee Middle School
  - 33 School Bus Drive, Oakland, ME 04963
  - www.rsu18.org/mms/
- *May 16th, 2015* – Ellsworth Elementary & Middle School
  - 20 Forrest Avenue, Ellsworth, ME 04605
  - www.rsu24.org/schools/eems/

- All registered teams will be kept appraised 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

Schedule for the Day

~~	(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

2015 Maine Robot Track Meet

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

Gold Standard

- 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 at each school was different. Some where compacted ash tracks, others asphalt, 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, some times it would be in the eighties, and sometimes in the rain.

The point being, each event was impossible to predict for. 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.

Good luck, 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.

Scoring:

- Awards will be given to each team winning an event. If enough teams register for an event we will have 2nd and 3rd place awards as well.
- Trophies, medallions, or ribbons 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 events x 3 pts = 21 pts*)
  - 3 points for first place
  - 2 points for second place
  - 1 point for third place
- In the case of ties for equivalent <u>overall</u> 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

NEW

- Team Name
- Coach name(s) and contact information
  - Phone, email, address
- Event location attending
- Event's being entered, number of robots, RCX/NXT/EV3/VEXIQ type
- Names of all team members **and t-shirt sizes**
- Registration payment (postmarked, paid, or purchase order)
  - Regular Registration: ($45/team member) on or before April 3rd, 2015
  - **Late Registration: ($55/team member) after April 3rd, 2015**
- Signed and returned release forms for all participants

- Registrations received after April 17th, 2015 will not receive t-shirts due to needing to put the order in… so plan accordingly.

Basic Guidelines:

- A team may compete by registering for one, several, or up to 7 events.
- A team is not limited in size.
- All members of the teams must be currently enrolled in grades 3 to 8, including home-school or alternative school settings.
- All members must have a signed consent and release form to participate in the track meet.
- Local teams may be organized as part of a schools 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.

- The Maine Robot Track Meet is designed to evaluate finished products in the form of robot performance or LEGO structural design.
  - In this respect it is very much like a track meet.
  - Robots may be of any shape or variety as long as they meet the robot rules outlined in that events' section.
  - 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.
    - However, 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!

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

Robot Rules:

1. A team/school/group may bring more than one robot.
   1. 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 (not wires, elastics, or string).
   1. However, joints, swivels, or other mobile parts are allowable.
   2. 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 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)
   1. Robot brains may be swapped between teams and team groups as needed to power different robots. So an NXT 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.
5. Equipment:
   1. Each robot may contain only a single RCX, NXT, EV3 or VEX IQ unit (brain)
   2. 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.
   3. No glue, adhesive, or other foreign parts are allowed.
   4. LEGO robots may only have LEGO parts.
   5. 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.
   1. For example: A robot that can go up a 60 degree slope must also be able to go up the 20 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.
   1. 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.
   2. For the Ping Pong Shot Put, see details under that event.

Robot Rules (cont.):

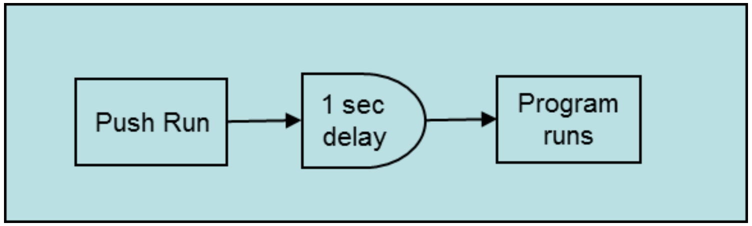
8. Power:
    1. No AC power adapters may be used on the robot (during competition).
    2. No external power supplies may be used on the robot
    3. Batteries and power used may not exceed 1.5 volts per AA battery or 9 volts total. Winning robots may be required to submit their robot for evaluation of battery supply.

9. LEGO or VEX weights are allowed

10. Communications during competition:
    1. No communications is allowed between the team and the robot during competition
    2. No IR Tower, Bluetooth or WiFi communication
    3. No RCX/NXT/EV3/IQ to RCX/NXT/EV3/IQ communication
    4. No Remote control devices of **<u>any type</u>**, wired or wireless

11. Sensors:
    1. 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:
    1. 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 at bottom of page. 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.

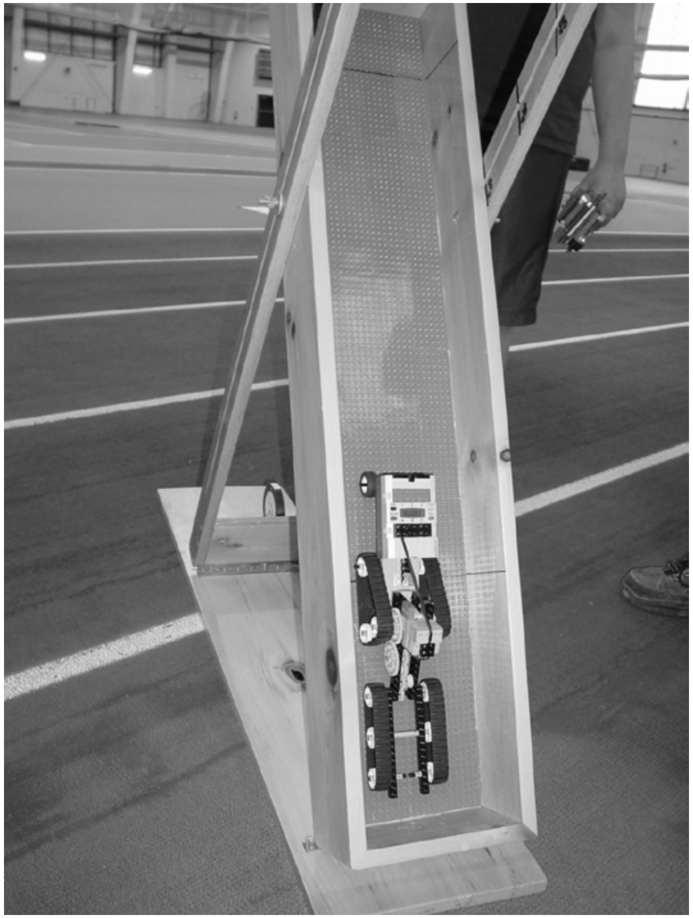


Notes from the Director

- 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 600,000,000 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!

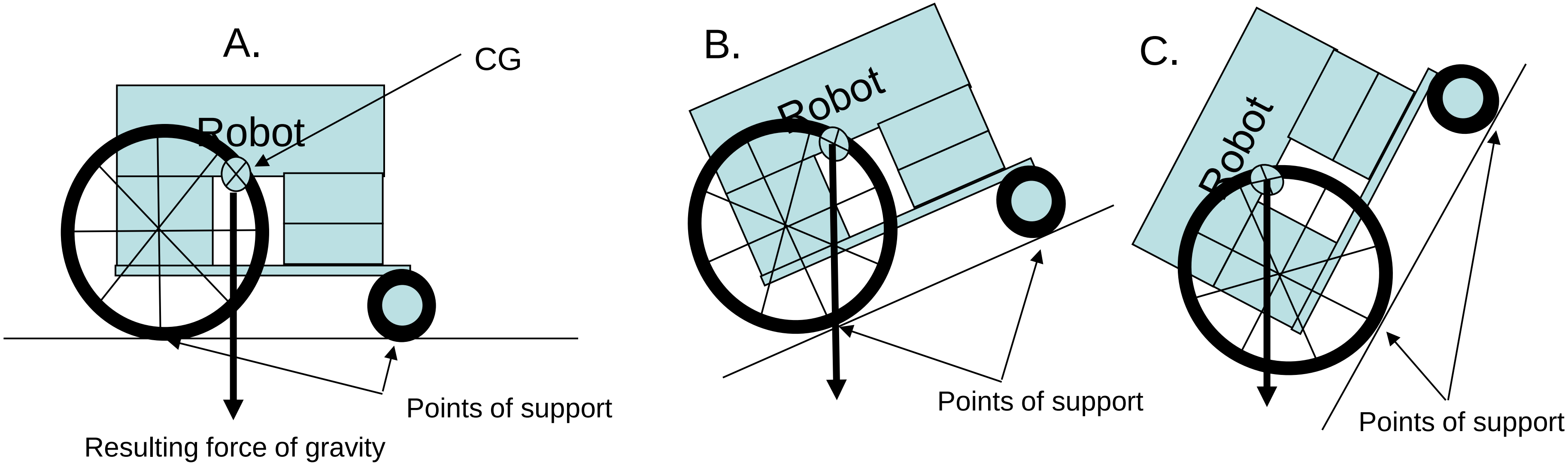
Event 1: Slope Climber

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



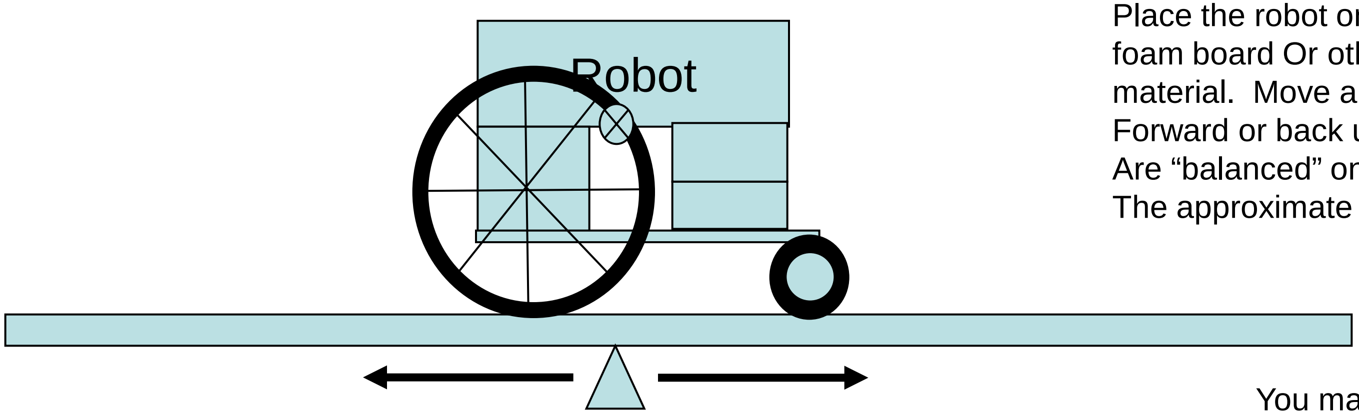
Note: This robot (winner that year) unfolded it's back set of treads after it got started. Otherwise would have been too long.

- Center of Gravity (cg)
  - For an object to be at equilibrium and stable it must be at rest with the center of gravity directly below the point of support (so no car is really stable since the CG is always above the tires). However, an object can be at equilibrium and still be unstable. This is what you will be attempting to achieve in this exercise. To do this the CG must fall between the supports of the object (or robot in this case)
  - Since the RCX/NXT is the largest contribution to weight for most robots, it is important to consider where it will be placed in the robot.
    - Example A: Gravity places the weight of the robot on all of the wheels (between points of support) - STABLE
    - Example B: This is showing maximum angle for the robot to still have weight being placed between the points of support (reality would likely cause this robot to fall due to instabilities) – INSTABLE (possibly stable at rest, but instable during motion)
    - Example C: Shows a robot that will fall backwards over its rear wheel because the point of supports are not beneath the cg. – INSTABLE even at rest
  - Experimentation to provide a **cg** that is between the wheels or supports will be necessary.



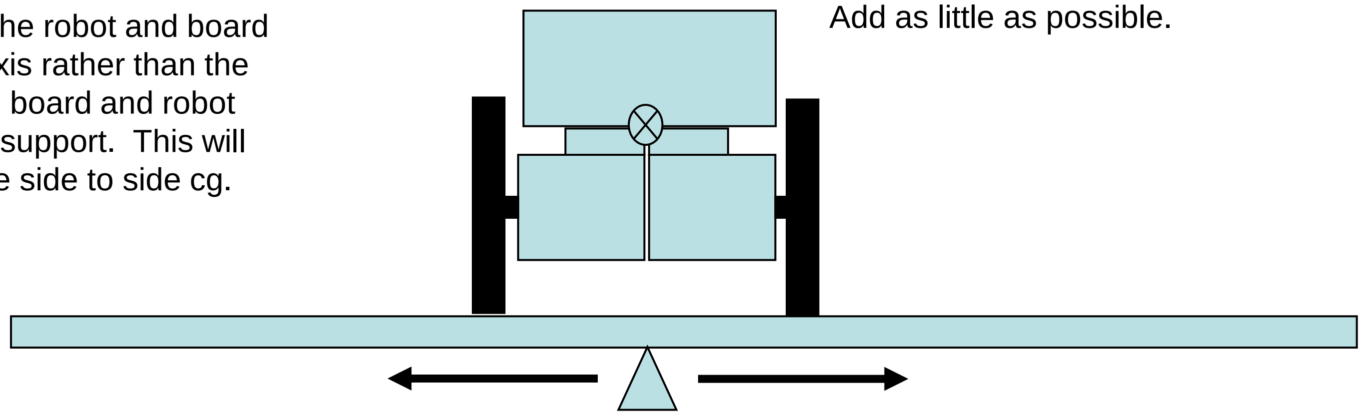
Checking Center of Gravity (cg)

Place the robot on the center of a piece of foam board Or other rigid but light weight material. Move a supporting wedge or roller Forward or back until the robot and board Are “balanced” on the support. This will indicate The approximate front to back cg.



You may have to use small pieces Of tape or other material to keep the Robot from rolling. Remember that Whatever you add will affect the cg, so Add as little as possible.

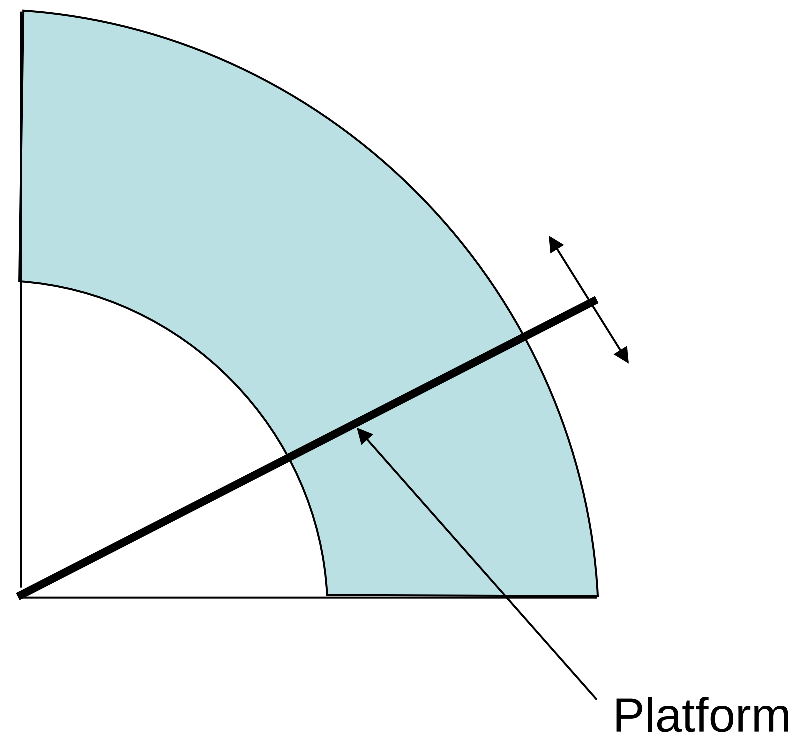
Now move the support so the robot and board Are resting on the length axis rather than the Width axis. Adjust until the board and robot Are again balanced on the support. This will Be approximately below the side to side cg.

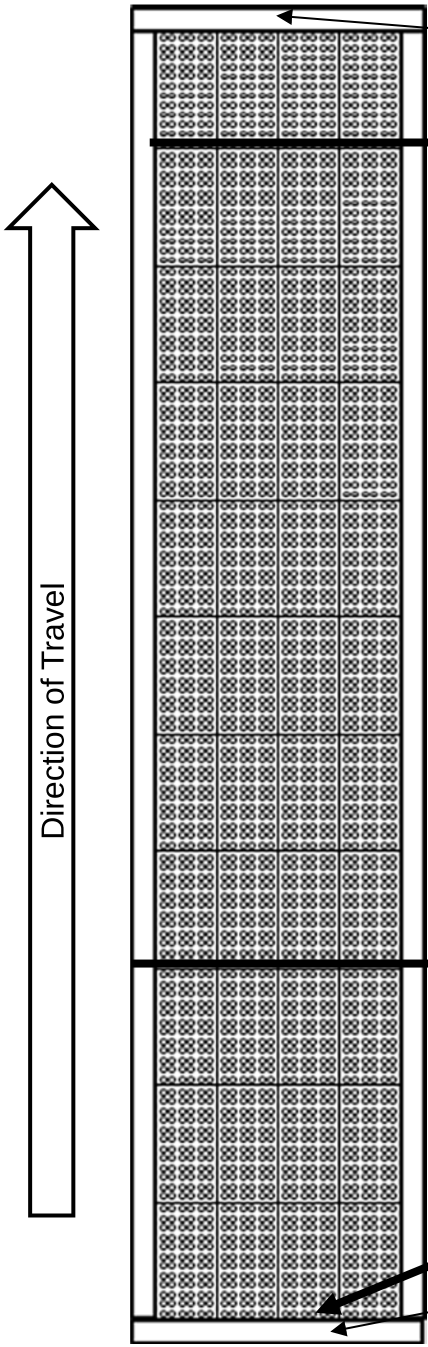


Climbing Competition:
Similar to a high jump competition
In that you continue to “raise the bar”
Until robots are eliminated.

- Platform is 24 knobs wide
- Platform is 132 knobs long
- Platform starts at a 30º slope
- Slope will increase to 60º in 10º increments.
- Slope will increase to 70 º in 5 º increments.
- Slope will increase to 85º in 2½º increments
- Robot may touch the sides, but may not clamp, grapple, or use opposing devises to gain support from the walls of the climbing platform.
- If robots tie for highest angle climbed, ties will be decided by fasted to make climb at that level
- Robots must complete climb within 75 seconds. Time is measured from time to start robot (not time to cross start line).
- Robot must work at all subsequent elevations to proceed. No modifications allowed between elevations **other than for weight distribution** (can move weights or RCX/NXT/EV3/VEXIQ around for better cg).
- Platform is bounded by 1”x4” (nominal) lumber to provide lateral and end barriers
- Inner dimension of platform is 37½ inches long and 7½ inches wide and covered with LEGO plates (built to accommodate plates, not lumber dimensions).

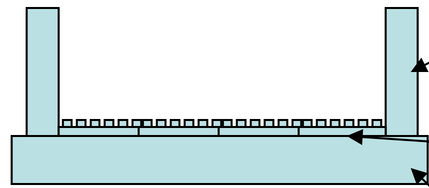
NOTE: The ultimate security of the robot is the responsibility of the team. If a Robot is starting to fall or slip Uncontrollable, it will be up to the team To “save” the robot from falling off and Damaging itself.





1”x4” butt end

Finish Line.
Timing ends as robot
First passes this mark.



1”x4” wood side

LEGO Plates glued to surface

1”x10” wood base
(or equivalent plywood)

Robot must start
Completely behind
This point. Timing,
If required, starts as
Robot passes this mark

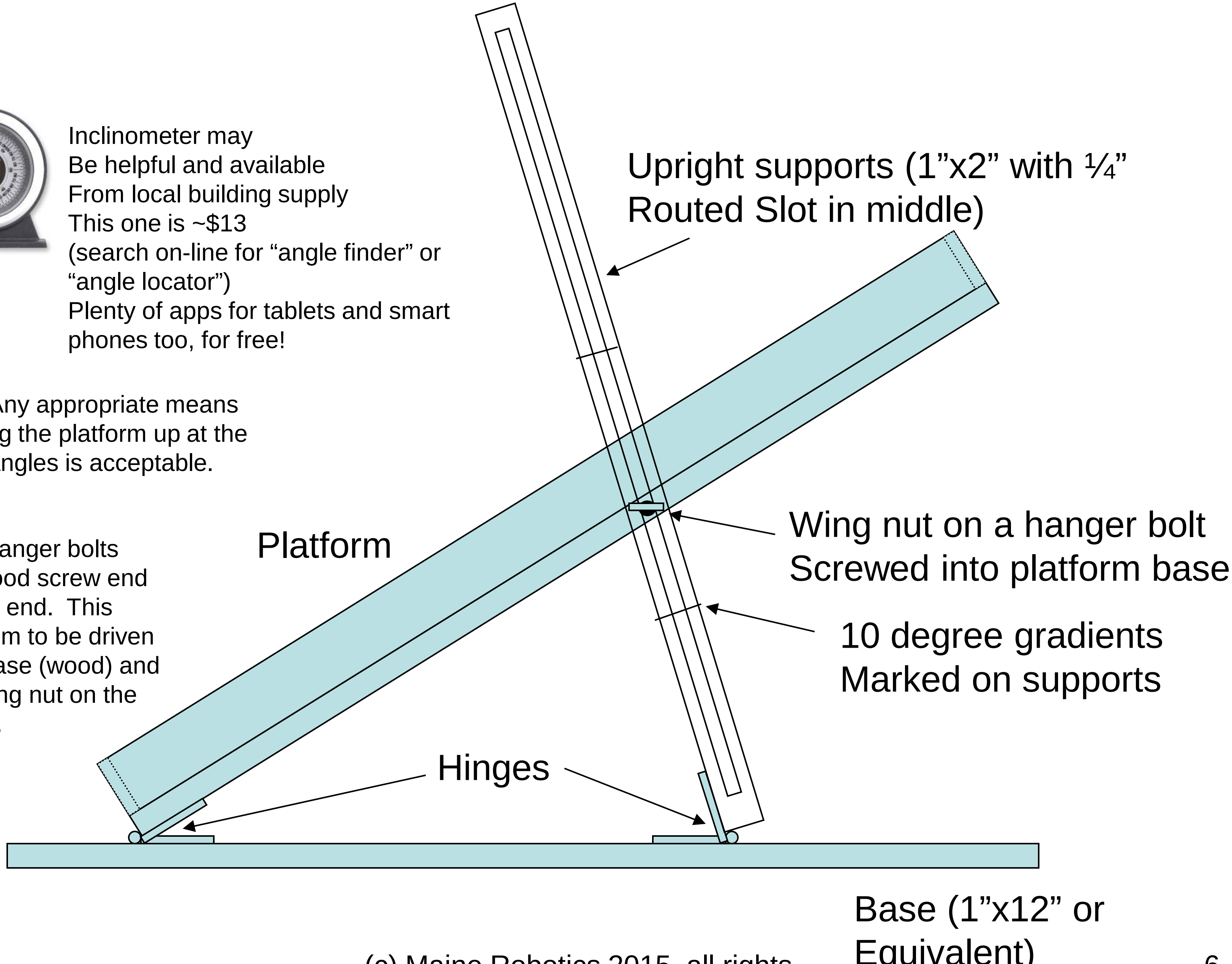
Robot starts butted at bottom

1”x4” butt end

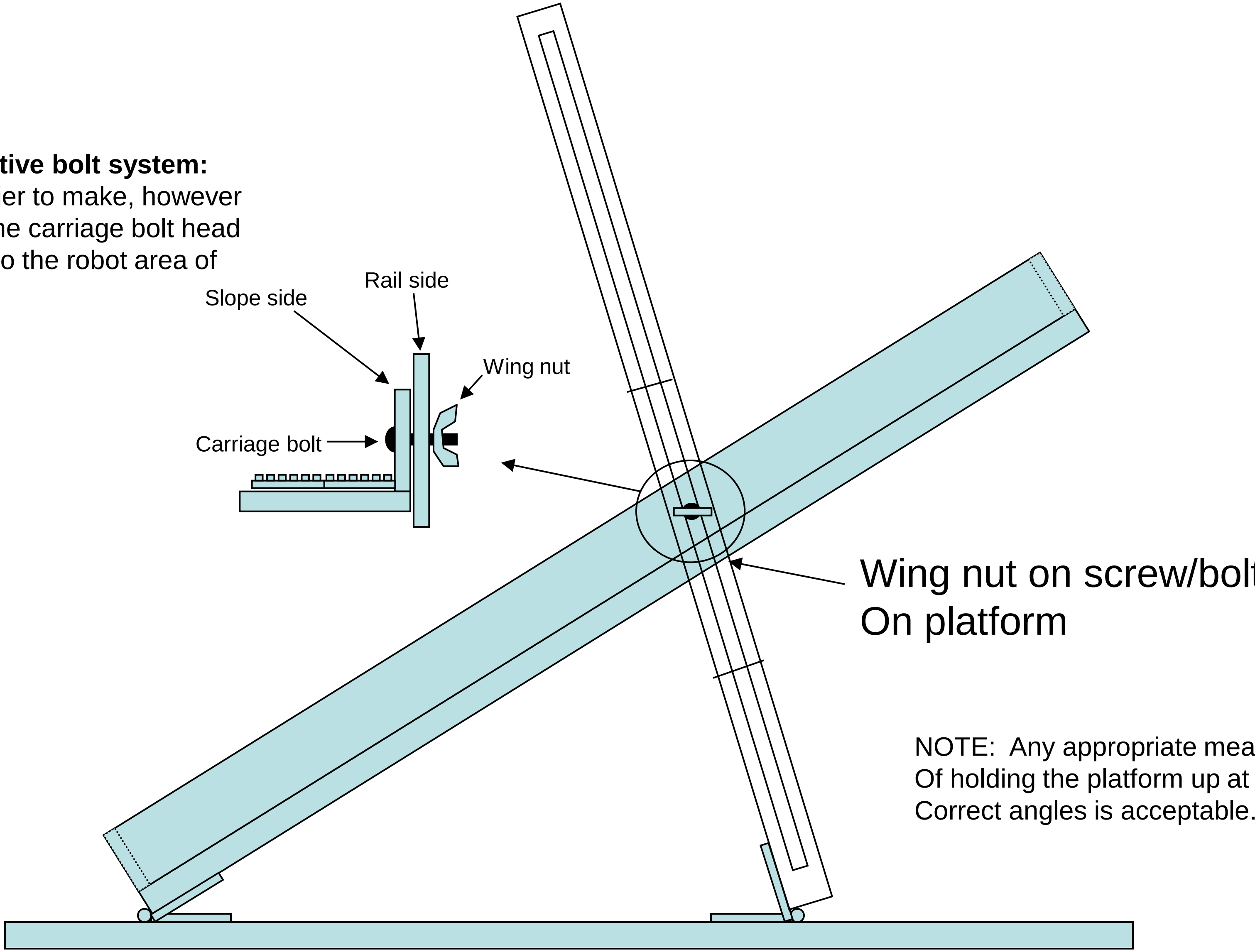
Inclinometer may
Be helpful and available
From local building supply
This one is ~$13
(search on-line for “angle finder” or “angle locator”)
Plenty of apps for tablets and smart phones too, for free!

NOTE: Any appropriate means Of holding the platform up at the Correct angles is acceptable.

NOTE: Hanger bolts have a wood screw end and a bolt end. This allows them to be driven into the base (wood) and have a wing nut on the other end.



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



NOTE: Any appropriate means
Of holding the platform up at the
Correct angles is acceptable.

Understanding Friction

http://www.physicsclassroom.com/Class/newtlaws/U2L2b.cfm#friction

Video explaining coefficient of friction (both static and kinetic)

https://www.youtube.com/watch?v=YoxbpInG2FQ

Understanding Center of Gravity

http://www.explainthatstuff.com/center-of-gravity.html

Video showing Center of Gravity, watch towards the end where they talk about Point of Support

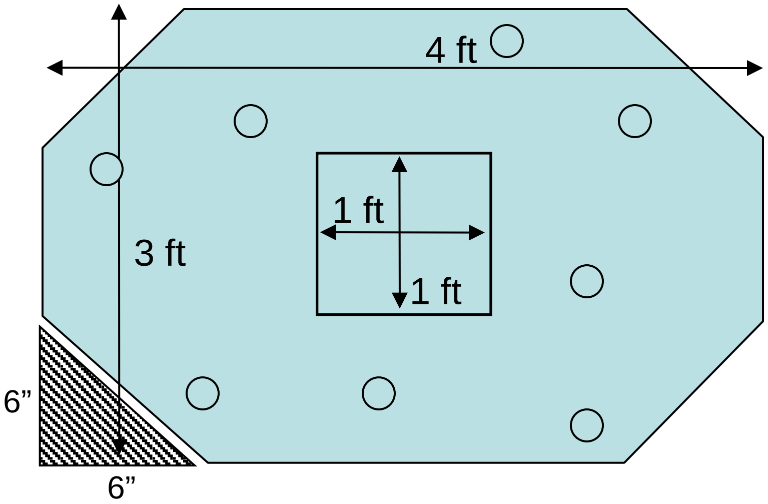
https://www.youtube.com/watch?v=YN2oALaRfL4

How Wheels Work

http://www.explainthatstuff.com/howwheelswork.html

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
- Each robot will have 3 trials to remove the greatest number of cans from the table surface. The highest score/time will be used for its ranking.
- Highest score goes to the greatest number of cans removed.
- 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.
- If the robot is touched by 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**.**



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.

Event 2: Table Clearing Mission

- Table construction may be made any way to meet the requirements.
  - The ones at the finals shall be made of ¾” 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 ½ feet from each side, and 1 foot from the top and bottom)
  - Each of the four corners need 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.

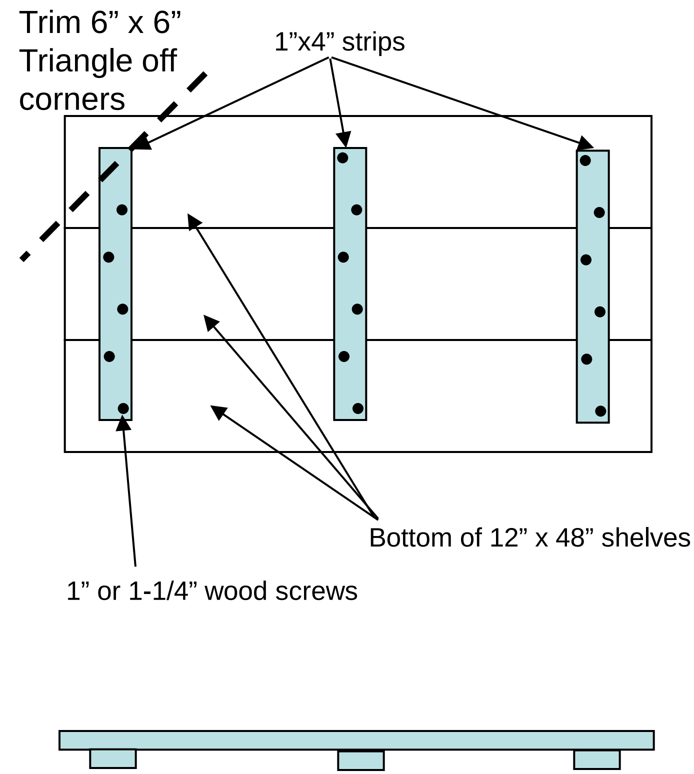
Event 2: Table Clearing Mission

- 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.

Event 2: Table Clearing Mission

- At the local mega hardware store 12” x 96” white shelves were listed at around $15
- At the same store a sheet of ¾” 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

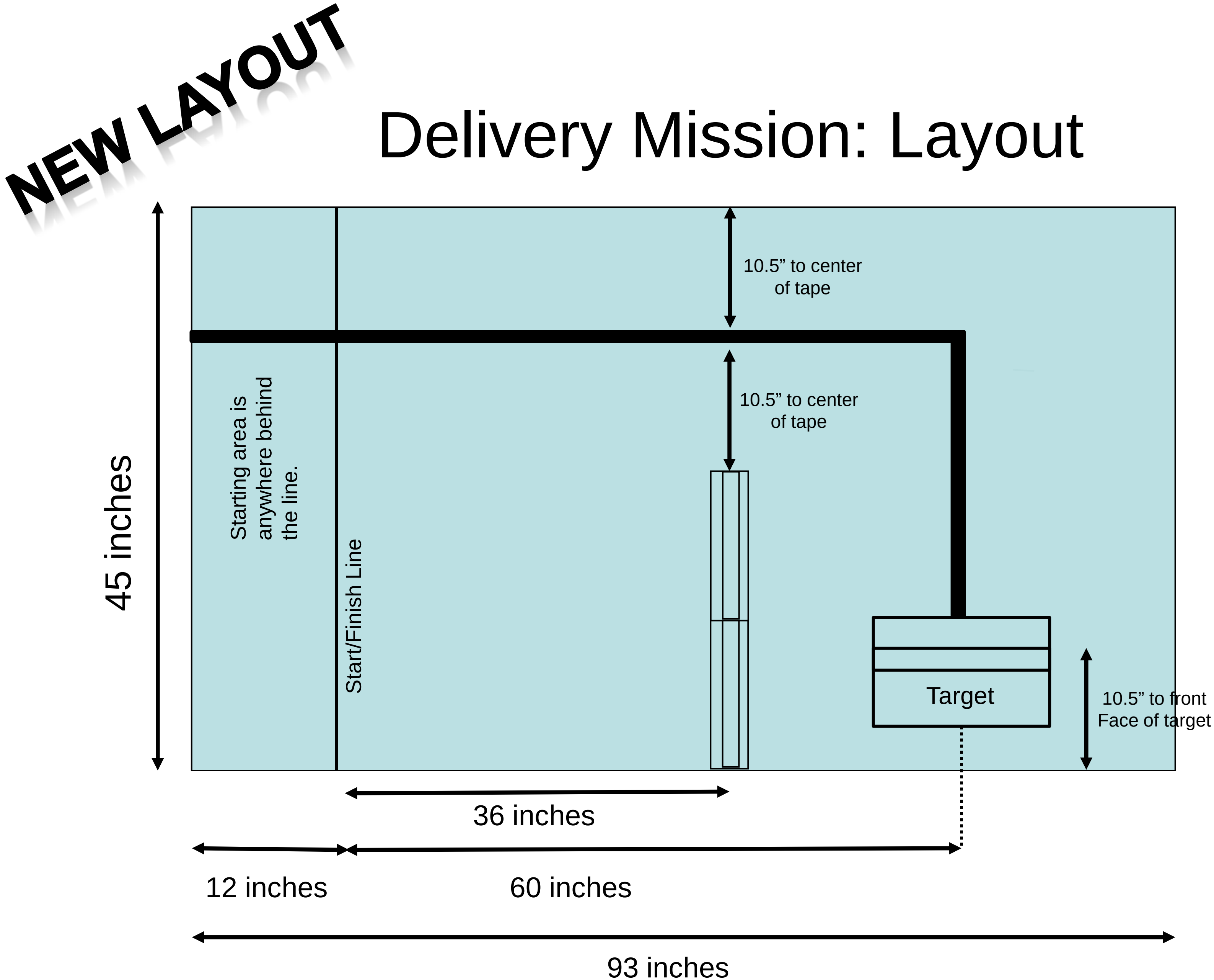


NEW OBJECTIVE

Event 3: Delivery Mission

- This event is designed for both building and programming skills!
- Robot will **carry** the LEGO® object and drop it through the target at the other end of the course.
- The robot must **carry** the object and then leave the item in order to score.
- How the robot delivers the object once in position (in front of the target) is up to the team.
- The robot may not throw or otherwise deliver the object from a distance greater than 6” from the target.
- The score is based on being able to deliver the object AND returning to the start line.
- Robot may not knock over or displace the target from its starting marks.

Delivery Mission: Layout



There will Be a ¾” black line finishing on center with the target and the starting area.

The “field” will be the back side of a FIRST LEGO League mat and measures 45” x 93” and is white.

Target dimensions

The target will be made of ¾” thick wood and be 11and ¼” wide (a 1x12” piece of lumber from a lumber yard will give you this dimension)

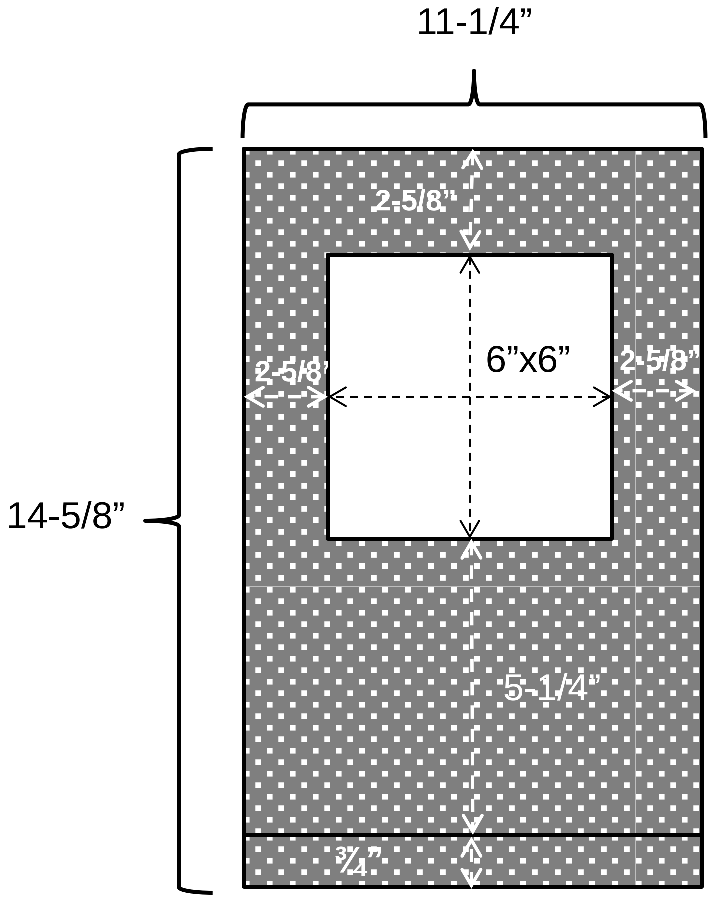
The base of the target is made from a 1x8” piece of wood (3/4” thick and 7-1/4” wide)

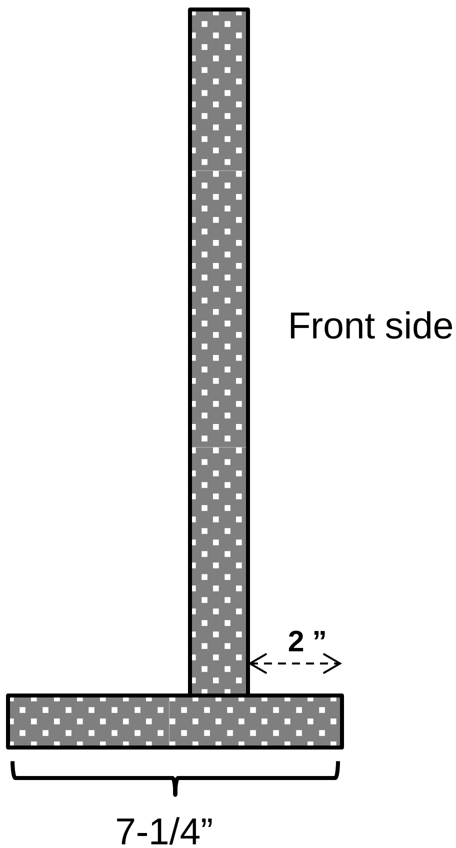
The entire target is 11-1/4” wide, 14-5/8” tall and 7-1/4” deep.

The vertical component is 2” back from the LEADING edge of the target assembly.

For practice, you could make this out of cardboard or plastic.

Ours will be painted white, if it matters…





Delivery Mission: The Target

- 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.
- A 6” x 6” hole located in the horizontal center of the target and 6” from the ground to the bottom of the hole.
- The base will be attached such that a 2” extension will be in front of the target face, so plan accordingly.

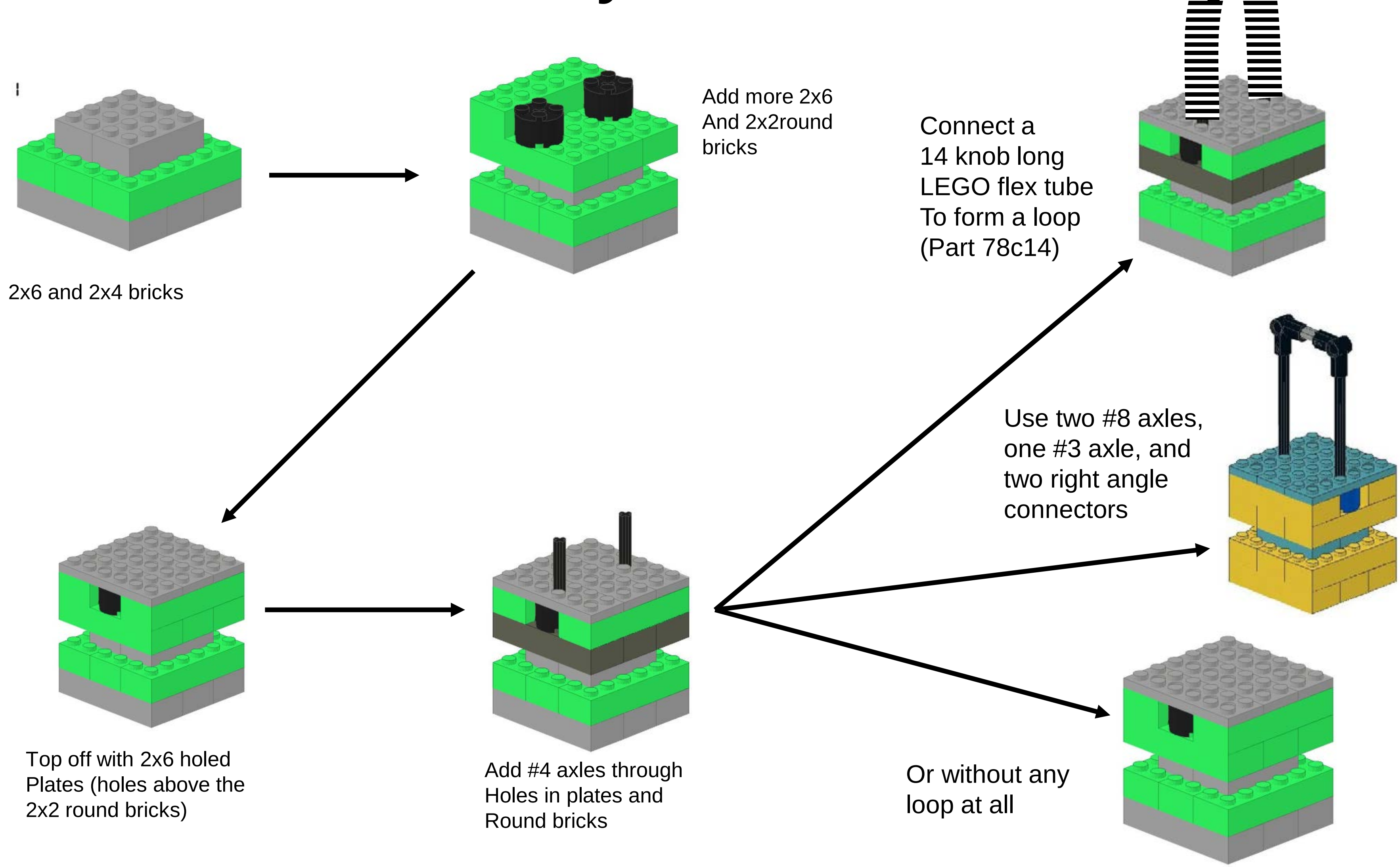
Delivery Mission: Scoring

NEW

- Qualification:
  - Object is **carried** by robot to target
  - Object is dropped through the target opening
  - Robot finishes back behind the start line
  - Barriers are in their original position
  - Target has not been knocked over or pushed completely out of its original start position
  - Robot remains on the playing area
    - “remains on” = drive wheels/treads are in contact with the playing field at all time.
- Time:
  - Ranking will be based solely on time to complete this mission
  - Time is from crossing the start line to returning to the start line after having successfully delivered the object
- There are no bonus points this year.

NEW

Event 3: Delivery Mission: The Object



Event 4: Fastest Robot

- This event is designed to see which robot can cover a set distance faster than any other robot
- The robot must transverse **18 feet** of floor
  - 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.
- The robot must **pass between** two end pylons that are 4 feet apart at the end of the **18 feet**.
- Robots that dislodge the pylons are disqualified for that heat.
- There are no markings on the floor for use as reference.
- The starting line is a 1 foot wide line, parallel to the finish line and **18 feet** away from the finish line.
- The robot must start between the start and back lines (12”)
- The robot that successfully completes the distance with accuracy and with the best time will be the winner.
- 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.
- No sensors are required for this event.

18 FEET!

Event 4: Fastest Robot

- The fastest robot event is designed to focus on the following:
  - Relationship between the mass of the vehicle, the force generated, and the acceleration obtained.
  - 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.
  - What is the relationship between acceleration and velocity? Velocity and speed?
  - What is the relationship between mass and weight?
  - What is the relationship between force, power and work?
  - What about potential and kinetic energy?
  - What is energy?
  - http://science.howstuffworks.com/fpte.htm is a good site to learn more, although they have more ads each year.
  - Gear ratios on the robot drive system
  - Also consider:
    - Mass of the drive system
    - Power level of the batteries
    - Friction
    - Stability (must remain on course)
    - Robust design (shouldn't fall apart)

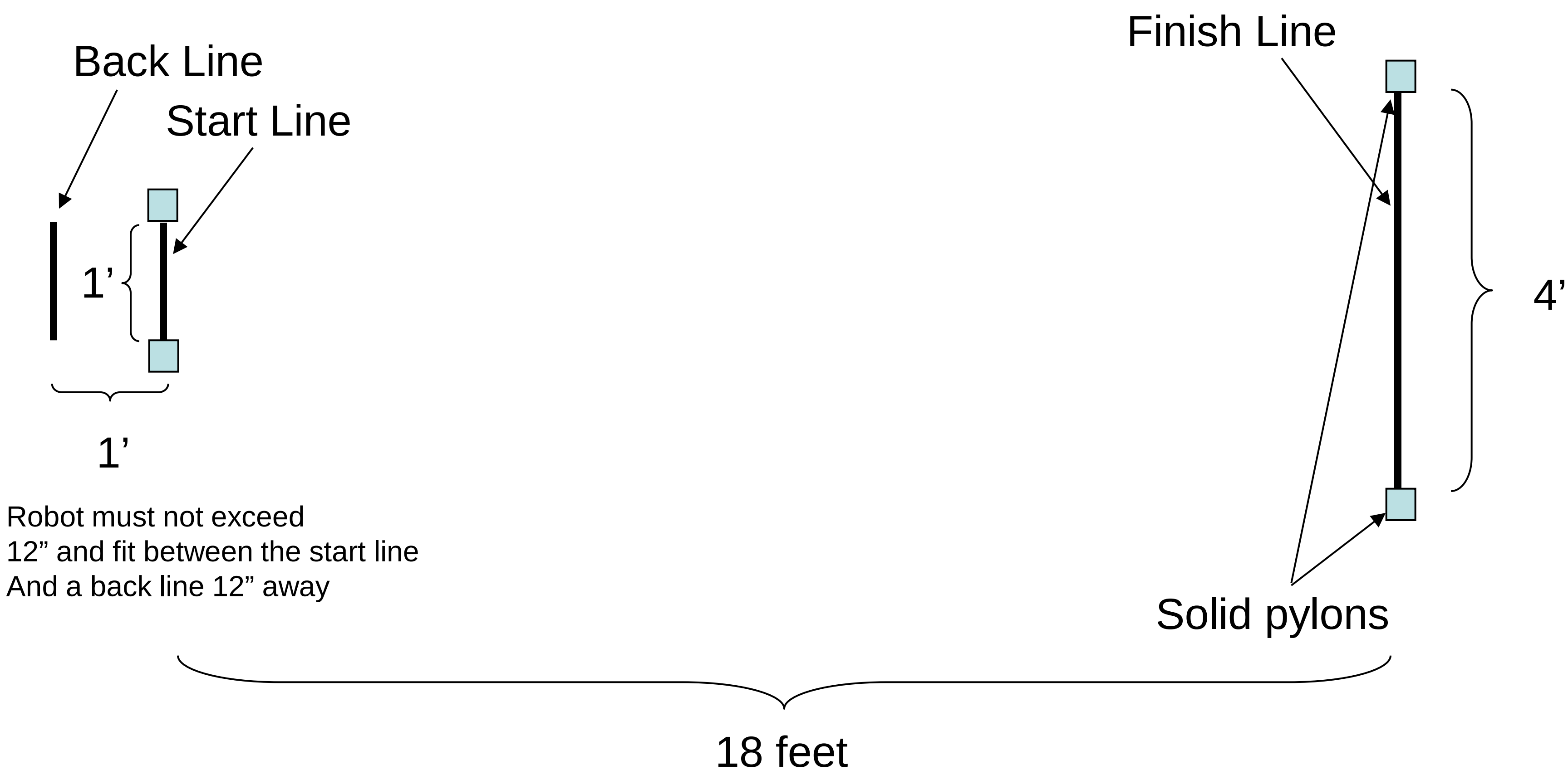
F=ma

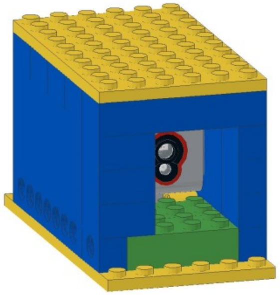
F=force delivered by the motors and powered by the batteries.
M=mass of the robot and all parts
A=acceleration of the robot when the force is applied.

Event 4: Fastest Robot, Cont.

- Many robots finish the 18 feet in 2.3 to 3.0 second time frame.
- Things to consider:
  - Adding motors increases the amount of force applied but also increases the mass of the object
  - In general, decreasing mass will increase acceleration
  - Power:
    - 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
    - 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)
  - 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)
  - We use laser lights and light sensors at the meet capable of measuring 1/100ths of seconds.
  - In the event of ties:
    - Best average of 3 trials will be used to break ties
    - Lightest robot will win if all times are equivalent.

Event 4: Fastest Robot





Making your own timer

- 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
- You can either
  - Attach both sensors to one controller such as an NXT or EV3 by “making” a longer wire (some soldering may be required) or
  - Use two controllers and communicate between them.
- http://goo.gl/HMfwCx for building the light trigger assembly and some simple programming directions

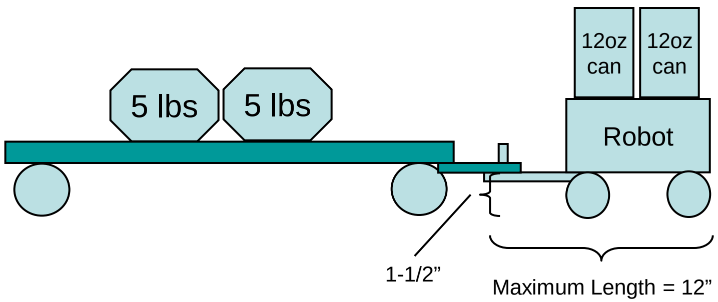
Event 5: Strongest Robot

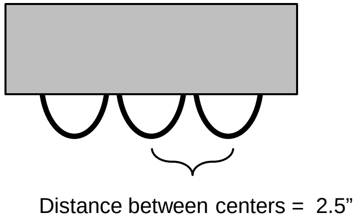
- In this event the robot must pull a weighted wagon across 2 feet of floor.
- The wagon will have **three solid loops** at 1-1/2 inches from the ground at the center front of the wagon for use in attaching to the robot. The loop will have an inside diameter of at least 1-1/2 inches and will not be thicker 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, ¼" thick U bolts (available at hardware stores).
- What a team uses for a wagon is immaterial except that an equivalent loop be provided at the same height for practice (our wagon uses **non-ball bearing axles**)
- The robot may only connect to the wagon at the loop and may only use LEGOs or VEX IQ parts to make the connection.
- Robot-Wagon Connection:
  - In this instance a connection refers to a point were 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.
  - MOST FAILURES OCCUR AT THE CONNECTION POINT, SPEND SOME TIME ON THIS BEFORE THE COMPETITION
  - Robot wires may NOT be used for this connection
- Weight shall be added to the wagon with a starting weight of 20 pounds plus the weight of the wagon.
- The weight will increase at 5 pound increments to **60 pounds** in an elimination competition.
- If more than one team can successfully pull 60 pounds over the two feet of course than those with the quickest time shall be the winners.
- Each robot may use as ballast any LEGO or VEX IQ parts AND one or two 12 oz cans of SODA or JUICE in original and full condition. These must be attached with only LEGO or VEX IQ parts and must be on the robot and completely off the ground. Use of such ballast is completely optional.
- The robot (not the pulled cart) must not exceed 12" in length, as measured between a "back line" and the "start line" and **must include the attachment to the cart.**
- Maximum time to transverse the 2 feet shall be **60 seconds**. Time for disqualification is measured from the time the robot starts until 60 seconds have passed. The qualifying time (used for tie breaking) is based on the time from crossing the starting line to the time crossing the finish line.
- The official may call a trial (cancel) if the robot has veered off course or fails to start after a reasonable time has passed.
- **All robots regardless of the number of motors will be in the same class**

Event 5: Strongest Robot

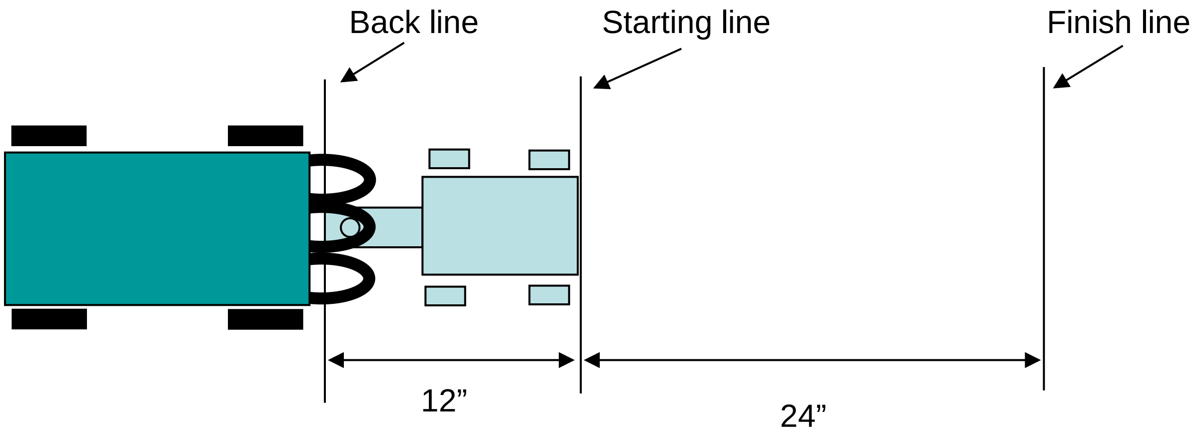
- The Strongest Robot event is designed to focus on the following:
  - Newton's three laws of motion
  - The application of gear ratios
  - The relationship between mass, weight, and friction
  - Integrity of mechanical structures

Event 5: Strongest Robot



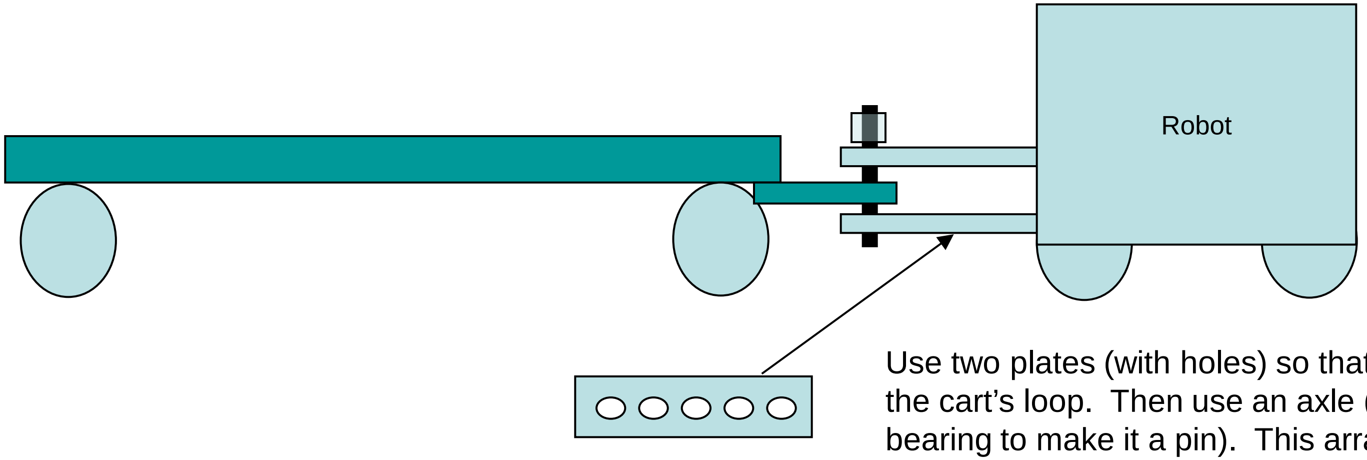


The front of the wagon will now have 3 loops for attachment. This allows for a variety of connections to prevent side movement during the trials



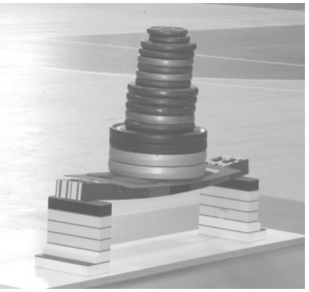
Event 5: Strongest Robot

- Connections have often been a problem for robots. Shown here is one simple, and strong method to connect to the cart:



Use two plates (with holes) so that they line up with the cart's loop. Then use an axle (shown here with a bearing to make it a pin). This arrangement is quick to use, as nothing needs to be removed other than lifting the pin out or dropping it in.

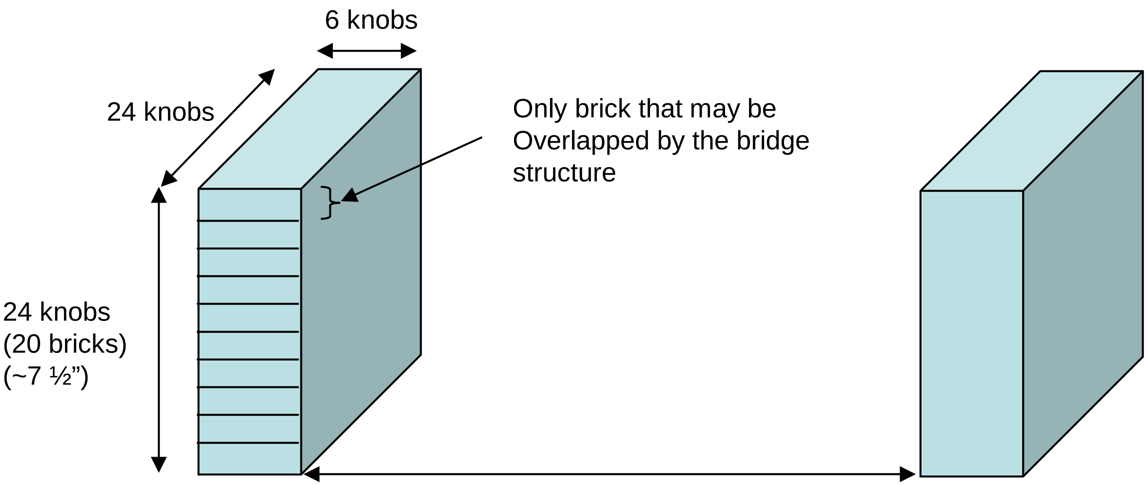
Event 6: Bridge Building



- In this event teams build a bridge completely of LEGOs without any electronic components. This is an engineering event not a robot event.
- Any non-electric LEGO parts are acceptable for this event except you may not use string, elastics, wires, and hoses.
- **The bridge must span 80 knobs (about 25 inches) so make sure the bridge is at least 92 knobs long!**
- The supports must be 24 knobs or greater off the surface of the table/floor or other supporting surface.
- 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.
  - The surface must be "paved" or otherwise constructed to actually hold the loads intended.
  - The surface must be accessible for loading from above
  - Since bridges can be loaded (in theory) with up to 80 pounds, consider how large a volume this would require and build accordingly.
  - The officials may disqualify a bridge if it is difficult or impossible to load additional weight without the load falling off.
  - 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).
- 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.
  - The following websites have a good introduction to bridge design and principles.
    http://www.howstuffworks.com/bridge.htm
    http://en.wikipedia.org/wiki/Bridge
- All weight loading is done by Maine Robotics personnel.

- Support structures at the end of the span are provided and are 24 knobs wide and 6 knobs deep (see diagram)
- The top of the support structures are at least 2 LEGO bricks high without any interference.
- A bridge end **may** attach to the support structure knob surface (top)
- A bridge end may overlap the first brick of the support structure only (see diagram).
- 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 bellow the 1 brick limit.
  - The span, with all loads applied must not touch the surface (table/floor) below the supports.
  - 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**.
- 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.
- Each bridge will be weighed at the beginning of the competition to determine the winner of any ties.
  - There is no weight limit to the bridges
  - In the event of a tie, the lightest bridge will be the winner
  - Weight is for the bridge only, not the support structures.
- **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.
- In 2014 several bridges tested could hold 180 pounds of weight without breaking (the amount of weight we had on hand).
- **Gold Standard: Bridge can hold 50 pounds**

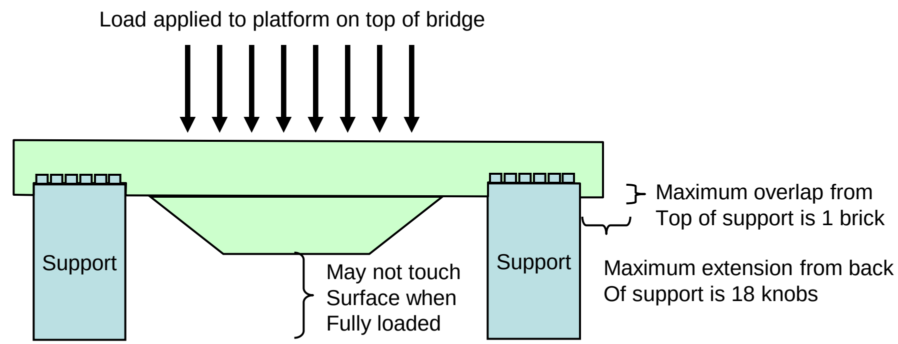
Event 6: Bridge Building



80 knobs
BRIDGE SUPPORTS AND SPAN

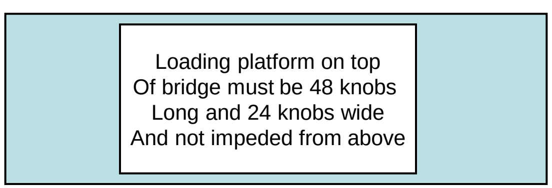
Note: The support structures may be built Differently than shown here. However, any Alterations may not affect the inside span, The top surface, or the top two bricks of the Support.

MAKE SURE YOUR BRIDGE IS AT LEAST **92 KNOBS LONG!!!**



The central portion of the bridge may extend beyond the One brick support restriction, however at all points around The support, the overlap may not exceed 1 brick.

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)

Event 6: Bridge Building

- The bridge building event is designed to focus on the following:
  - Compression and Tension
  - Force, mass, weight, and gravity
  - Comparative strengths of architectural design
  - Stress and torsion
- It is also included as a non-robot event, allowing a team with limited electronic components to compete in an additional event.

Event 6: Bridge Building - Stresses:

- **Compression** is the decrease in volume of an object when compressive stress is applied to the object. Different materials have different compressive characteristics. For example concrete has a very high compressive strength, but when exceeded results in structural failure. Steel also has a high compressive strength, but when exceeded results in buckling. String has no compressive strength (imagine pushing on two ends of a string?)

- **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.

MODIFIED

Event 7: Ping Pong Shot Put

- The Ping Pong Shot Put event is designed as an overall robot design project
  - Development of a system of components that can accomplish a task.
  - Non-mobile robot (robot base doesn't move)
  - Delivery of objects (ping pong balls) to a container.
  - There will be only one (1) class of robot (auto feed)
  - Manual triggering is allowed by use of a touch sensor
  - Three (3) trials to get the highest score

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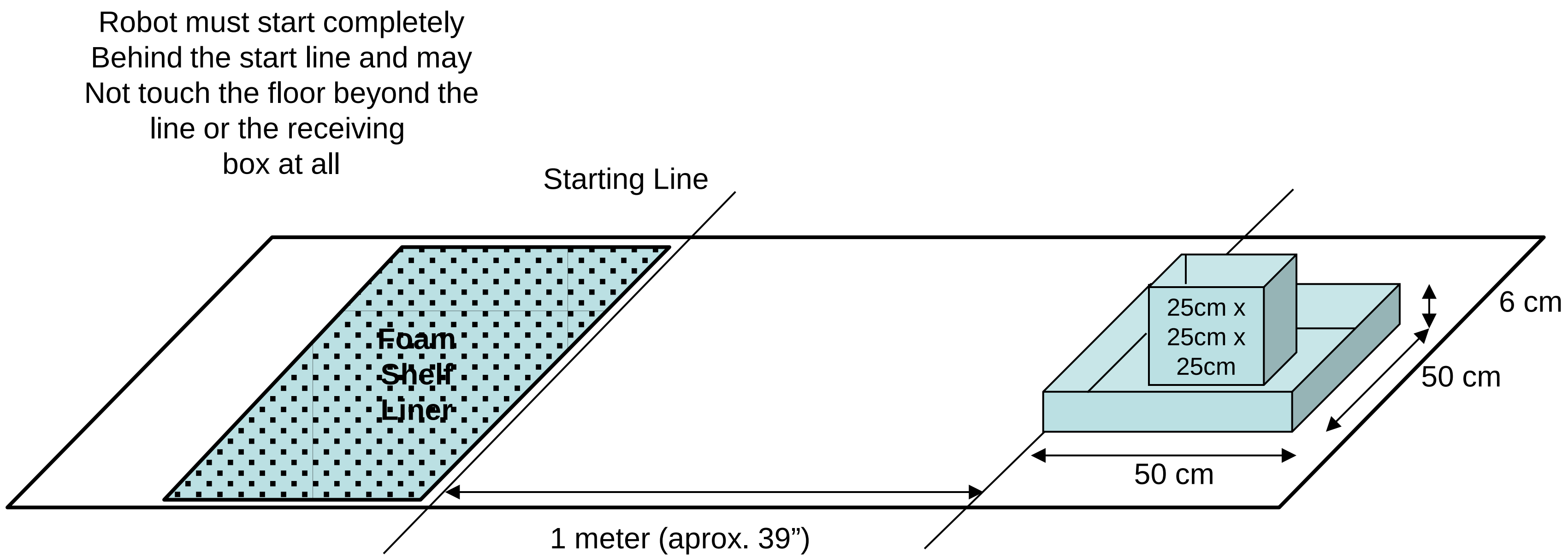
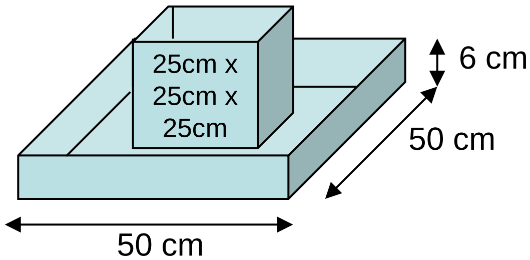
Event 7: Shot Put layout



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.

Event 7: Shot Put layout



Receiving box-low:
1 points for each ball delivered

4 sides
50 cm on a side
Made from 3/16" (5 mm)
White foam board.
Taped on all sides.
Floor inside box will be lined with felt sheets (or equivalent), cut to fit.

Attached directly to floor or table

Receiving box-high:
3 points for each ball delivered

4 sides, and bottom.
25 cm on a side
Made from 3/16" (5 mm)
White foam board.
Taped on all sides.

The bottom will have a Piece of cloth or foam to Prevent "bounce-out" of Delivered balls. It must be confined to the Bottom inch of the box.

The box is secured lightly To the floor with tape to Prevent minor movement.

MODIFIED

Event 7: Shot Put

- The robot must start completely behind the start line and may not touch the ground beyond the start line at any time during the competition.
- The robot must sit on the event surface (cannot be placed on boxes, etc.)
- 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)
- The robot may not touch the receiving boxes
- Ping pong balls:
  - If a ball becomes “lost” it may be retrieved by the team and reused.
  - The balls may be thrown, bounced, or dropped into the receiving box
  - 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.
  - All Balls will be the standard Table Tennis diameter **40mm balls.**
    - This will replace any existing 38mm table tennis balls.
    - 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.
    - Both the 38mm and the 40mm balls fit in a 5 knob wide x 4 block/1plate tall space.
- Teams will have a standard
  - “on your mark”
  - “get set”
  - “go” to begin
- Trials
  - Each team will have three (3) trials in direct sequence to each other (no delay’s between trials)
- Each trial:
  - will be for 30 seconds from “go”
  - at the end of 30 seconds scoring will be the number of ping pong balls in the receiving boxes.
  - If a ball is in delivery at the end of the trial’s 30 seconds, but not yet delivered it will not count.
  - Each ball delivered to the low receiving box will earn 1 point
  - Each ball delivered to the high receiving box will earn 3 points.
- Setup:
  - Each team will have *two (2) minutes* to “zero in” their shot put launcher. During this time, the team can shoot some ping pong balls, align their robot, and secure it with tape.
  - It is important for teams to work on this setup process
    - Can their robot be moved easily?
    - How long does it take to setup?
    - How long does it take to load?
    - How long does it take to zero in?

MODIFIED

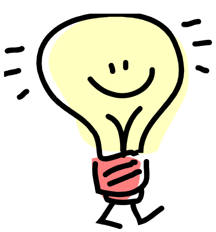
Event 7: Shot Put

- **Classes:**
  - 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
    - 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.
    - There is no limit to the number of balls held by the robot
    - 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.
- **NEW: Robot –table surface:**
  - 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.
  - ***No tape will be used*** as a result of this new method of preventing robot slipping.
- **Sensors:**
  - The robot launch mechanism **OR** the robot feed mechanism may incorporate a human operated trigger mechanism.
    - 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.

Event 7: Methods for Ball Delivery

- Teams have chosen a number of methods for how they will deliver the balls
- We have listed here some of those. Do not feel limited by these, but rather use this as a starting point.

- ➢ Bounce on surface to goal
- ➢ Pitching Machine style
- ➢ Catapult
- ➢ Rotating striker (think t-ball)
- ➢ Linear striker (think pinball machine launcher)



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
- This event uses a prescribed set of parts in a container on a table (provided by Maine Robotics).
  - Several extra bushings and black connectors will be in each container just in case some go missing. Competitors must inform officials if there are parts missing PRIOR to the start of the trial, so check quickly.
- Each contestant builds the **Simple NXT Robot** or **Simple EV3 Robot** during the match
- Directions for the Simple NXT or Simple EV3 Robot can be found at http://trackmeets.mainerobotics.org
- NOTE: The robots will be programmed ahead of time to drive forward. You just need to build it and hit run.
- There will only be one program on the NXT or EV3.
- 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.

- Robot must be completely built
- Robot must be built according to the specs in the online documents
- Robot must be able to drive forward
- All parts must be completely disassembled prior to the start of the round
- Contestants may layout their parts prior to the start of the round (a one minute time will be allowed for setup)
  - We highly recommend you turn on your robot at this time to save time later.
- No directions are allowed during the event
- Each round will consist of:
  - 1 minute setup (contestant may arrange, but not connect parts)
  - 6 minute build and run (maximum time allowed)
- Each contestant will have two trials to get the fastest and most successful build
- 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)
- The best of the two trials will be used for the winner

Event 8: Robot Speed Build

- 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.
- ***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.
- ***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.
- The world record is 2 minutes and 1 seconds! Set in 2014, go Paige!

MODIFIED

Event 9: Steeplechase

- 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.

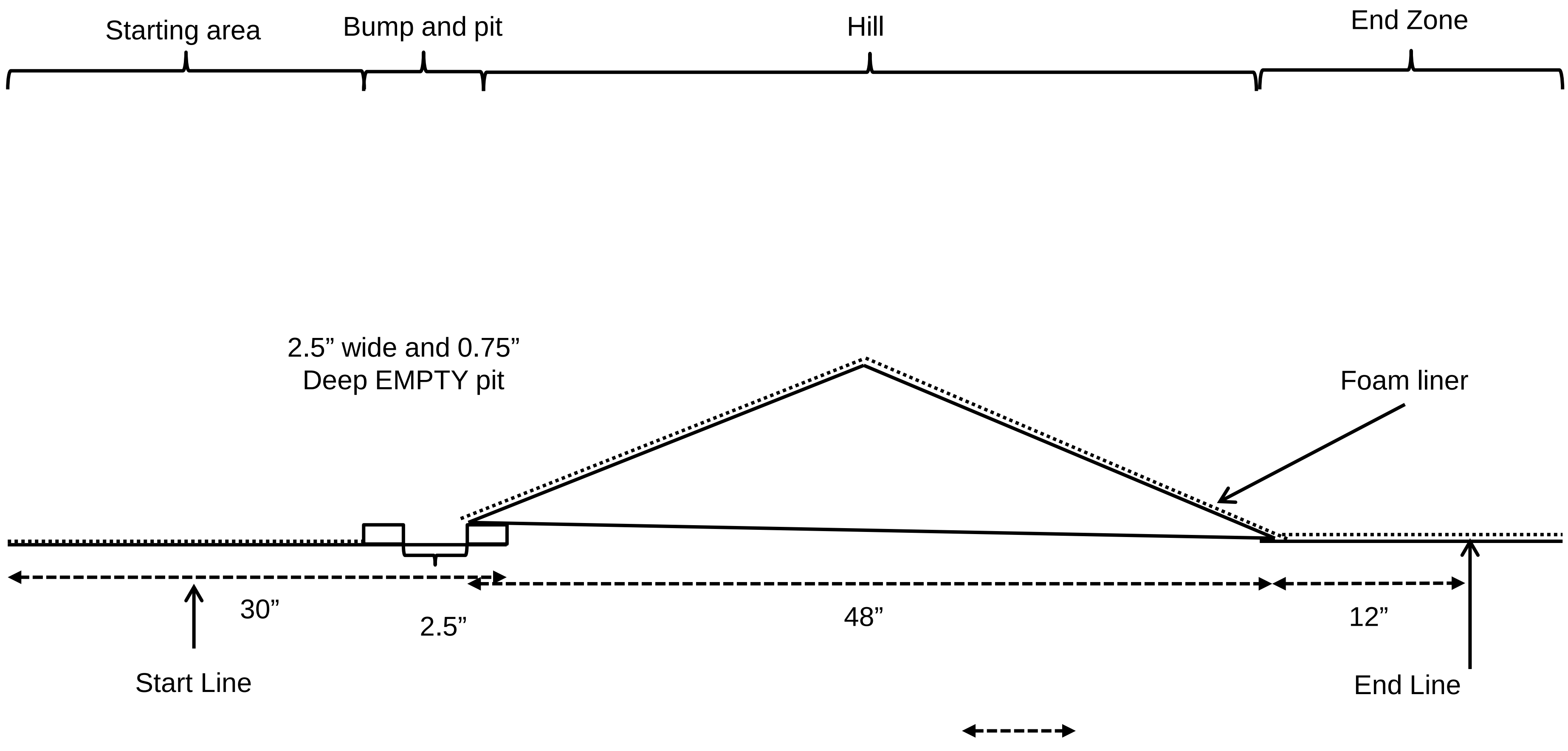
Event 9: Steeplechase

- The Steeplechase is a terrain obstacle course for your robot to cover
- Robot must start within the 1 foot x 1 foot starting square
- Robot must cross/cover/navigate any obstacles between the start and finish lines
- Robot must have a LEGO figure “rider” on it’s LEGO robot “horse” and the rider must finish the coarse without falling off.
  - Rider may only be attached by standing or sitting on LEGO knobs
- 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 falling off either the hill or the landing
  - Disqualifications:
    - The robot leaves the course completely (usually falling off)
    - The robot partially leaves the course and cannot get back on (hangs on the edge)
    - The robot becomes stuck at a transition point (the pit or the peak usually) for more than a count of 10
- Leaving the course will result in the end of the trial and subsequent scoring
  - If a robot fails to complete the course, the time will be the time at which the official determines that any of the conditions under previous bullet are true. The team may “throw in the towel” if the robot is hung up and ask the official to stop the timer, but that would also end the trial. There is no limit on when the team may call the trial.
- 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.
- Best of three trials

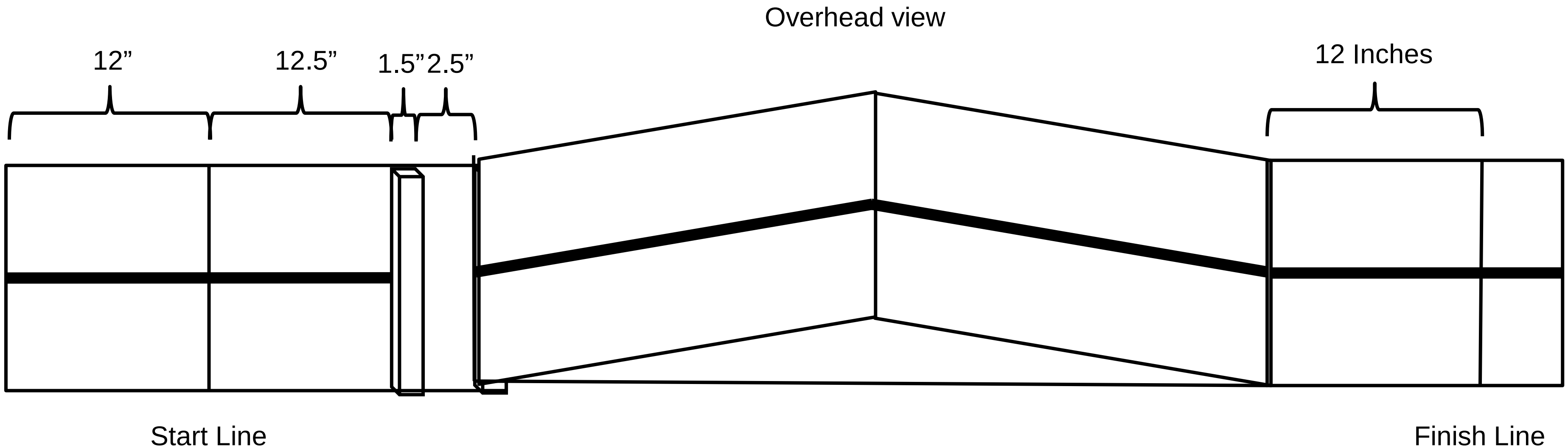
Event 9: Steeplechase

- Challenges:
  - 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.
  - Make it over the pit and completely onto the hill.
  - Climbing the hill. You must climb a 22° slope
  - 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.
  - Reaching the end of the hill.
  - Reaching the finish line.

Event 9: Steeplechase



Event 9: Steeplechase



Ramp starts at the end edge of the pit with the second 1.5”x0.75” block supporting the end of the ramp

End zone can either be just a piece of shelf liner on the floor, or use a second piece of ¼” plywood for the base and cover with shelf liner.

MODIFIED

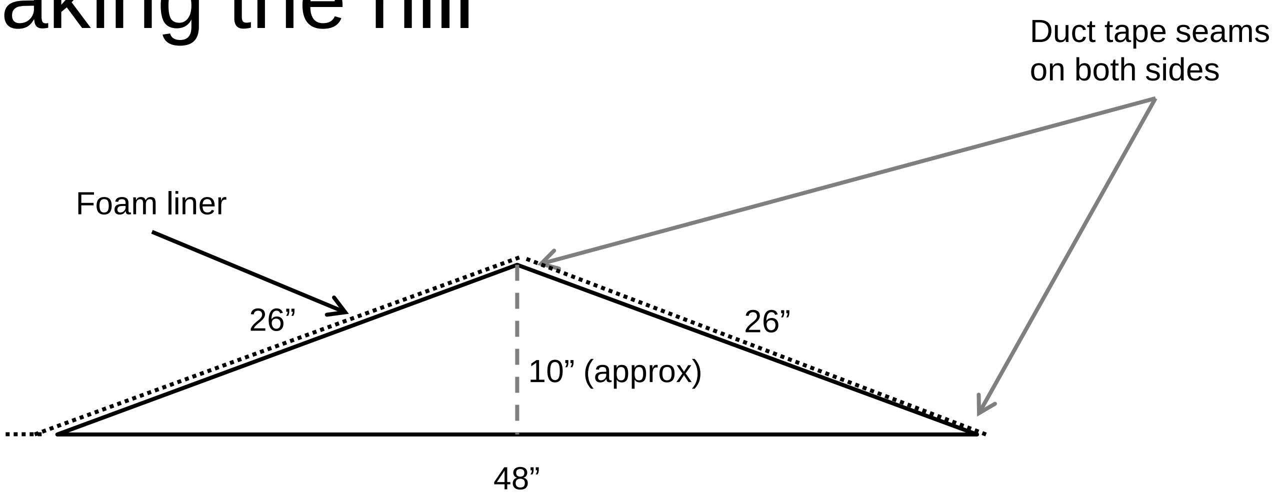
Event 9: Steeplechase

- Scoring:
  - Get all wheels/treads over the bump — 10 pts
  - Get all wheels/treads onto the hill and out of the pit (crossed the pit) — 10 pts
  - Climb the hill, reach the peak — 10 pts
  - Cross the finish line — 10 pts

- Scoring and ties:
  - Winner is the robot with the highest score
  - If multiple robots tied at the same score, then goes to the robot/rider with the lowest time to completion.
  - If there is still a tie, then it goes to the robot with the highest accumulative score (all three runs)

Event 9: Steeplechase

- Making the hill



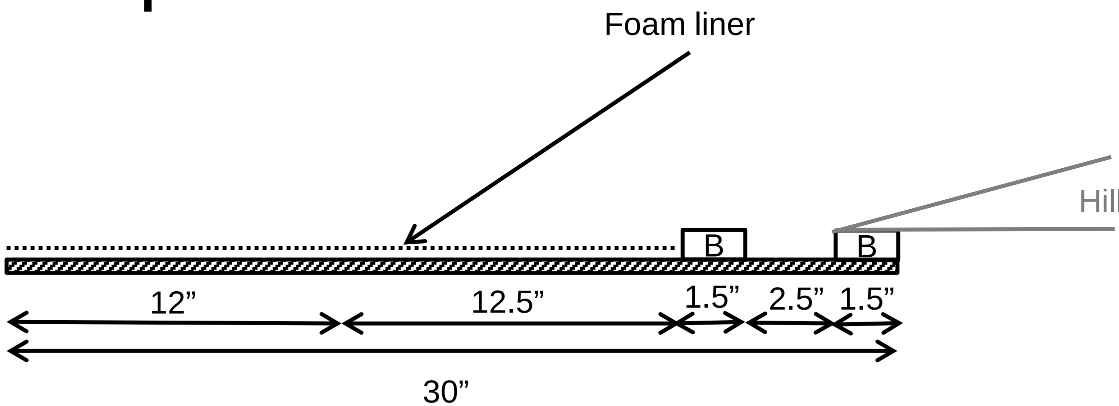
(2) 26” x 12” - ¼” plywood pieces
(1) 48” x 12” - ¼” plywood piece
Duct tape to seal corners
12” wide foam shelf/drawer liner
(we use **Duck Original Easy Shelf Liner** and glue it down with spray contact adhesive, but taped along edge would work as well). Note, not the Easy Select Shelf Liner

Joints can also be wired together for greater durability. Just drill holes at edges and thread a small gauge wire through the holes and tighten by twisting, then cover with duct tape.

Competition hills will be reinforced with wood.

Event 9: Steeplechase

- Making the pit



One 30” x 12”, ¼” plywood piece
Two 12” x 1.5” 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).

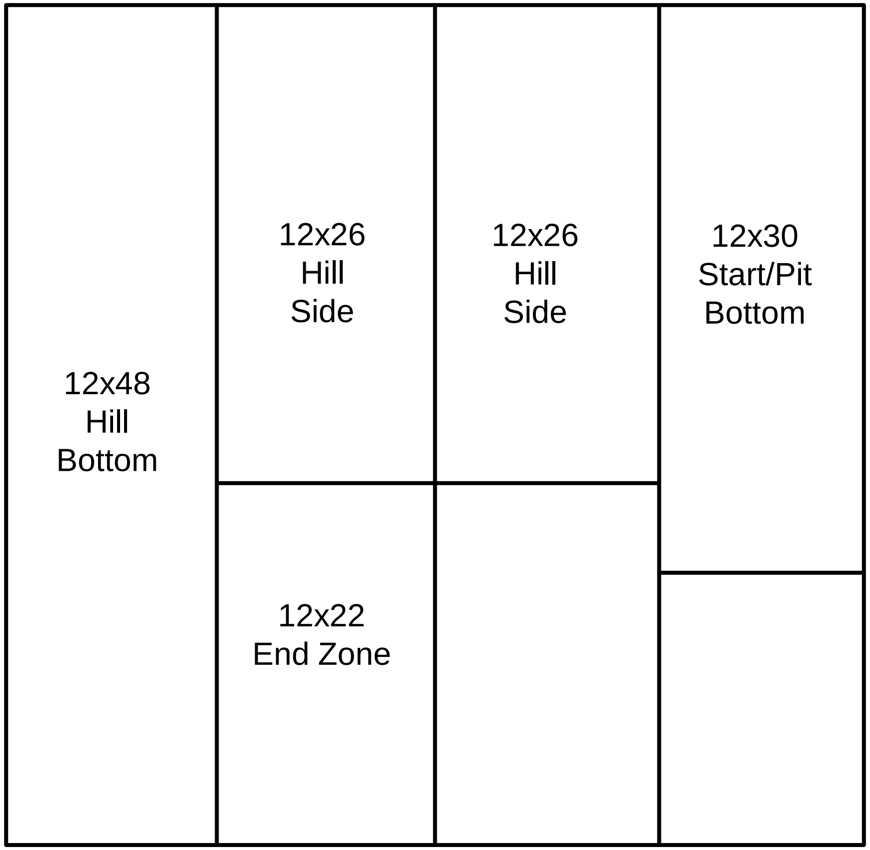
Event 9: Steeplechase

Cutting the pieces for the event

4 foot x 4 foot
¼” plywood or
Luan plywood

NOTE: tends to be
splintery so sand the
edges or edge with
duct or masking tape

All dimensions are
within ¼” when
possible to allow for
saw kerfs and
variations in assembly



Event 10: Walking Robot

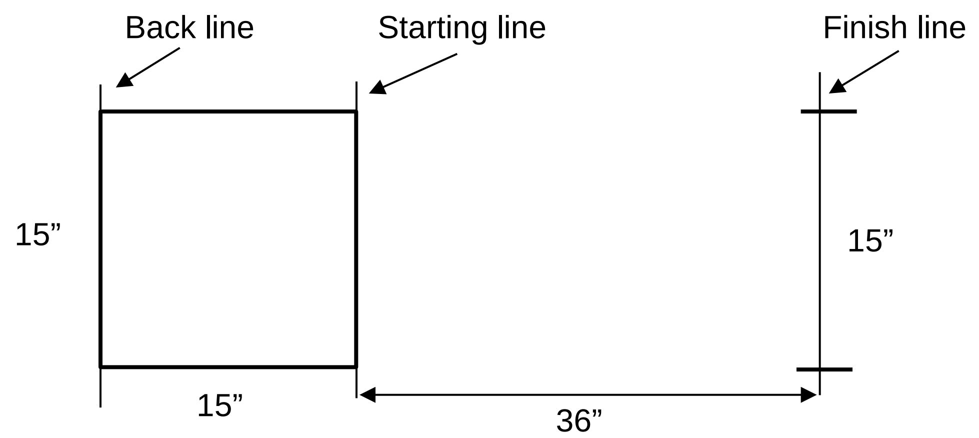
- In this event, walking robots must cover a three foot distance. Fastest qualified time wins.
- Robot must start within a 15” x 15” square found behind the start line
- Time to transit the course is measured from the time the robot touches the “start line” to the moment it touches the “finish line” and must touch the finish line between the 15” wide markers.
- Robot must have a one second pause at the beginning of the program
- Entire robot (RCX/NXT/EV3/IQ, motors, body, wires, etc) must be one unit
- 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.
  - 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.
- Robot is not limited to the number of legs or to the articulation style of the legs or mobility system, except as prohibited here.
- Robot need not completely “lift” its legs from the floor to move forward
- Robot body may not touch the ground during the gait cycle, other than incidental touching (left to the discretion of the officials)
  - A robot body may have some legs that are rigidly attached to the body while others are mobile
- To compete the robot must reach the finish line without being disqualified
  - Must complete run within 60 seconds from time it touched the start line
  - Must not be touched by humans
  - Robot body must not touch the ground (see above)
  - Robot may not fall over
- 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.

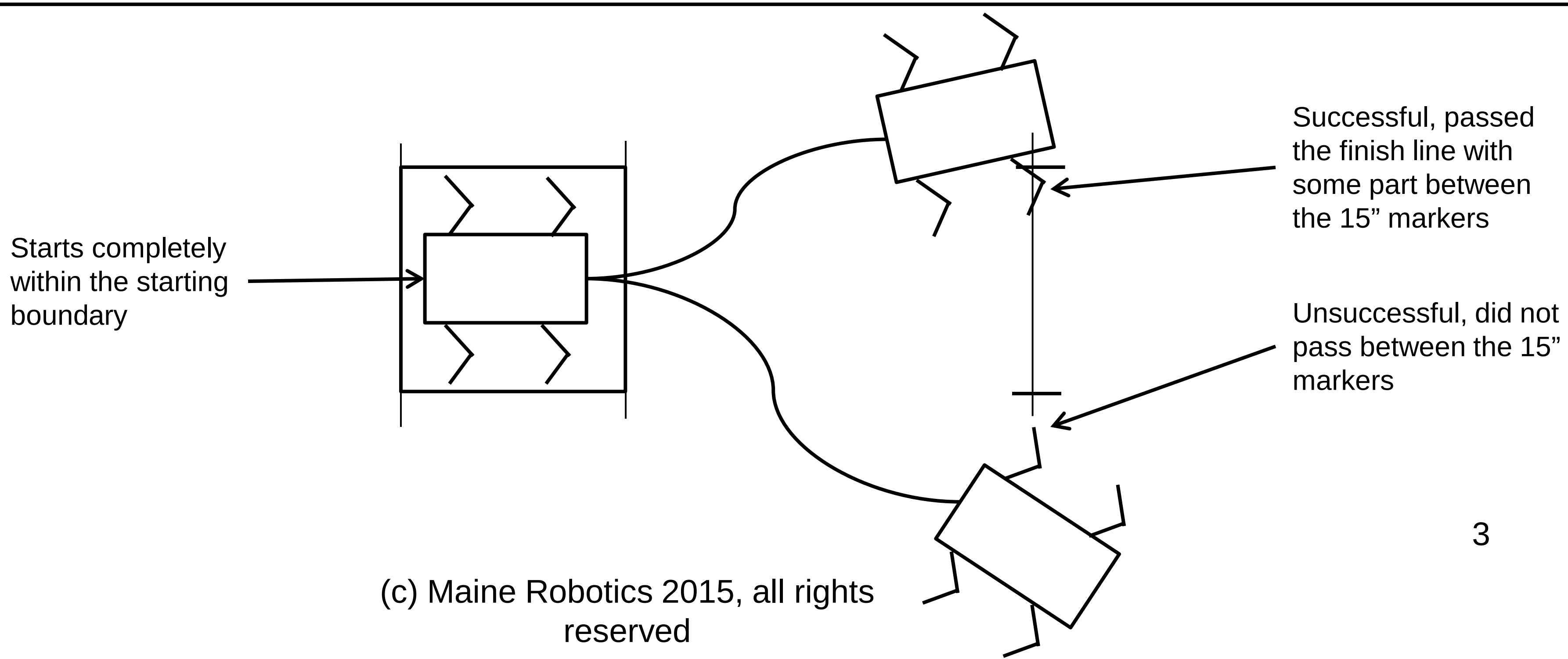
Event 10: Walking Robot

- The Walking Robot challenges builders:
  - To understand more complex building challenges
  - The application of linear motion using weight distribution and balance, non-wheeled motive power, instabilities associated with a higher center of gravity
  - More complex programming
  - Integrity of mechanical structures

- Please understand the difference between walking and flopping. Walking is good, flopping is not.

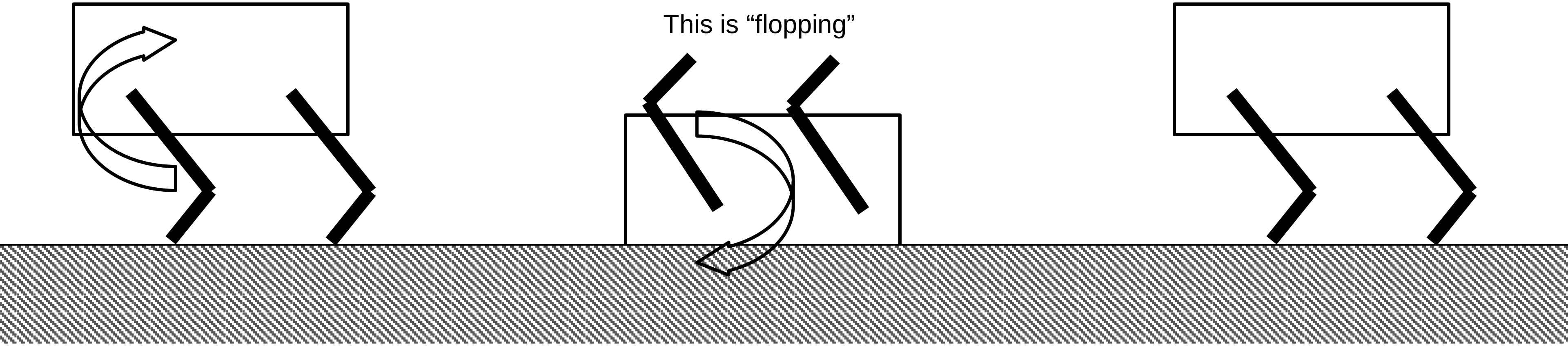
Event 10: Course

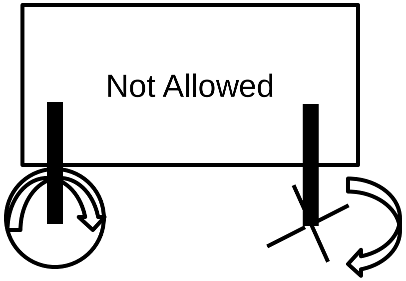




Event 10: Body Must be supported by legs

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.

Event 10: Terminology

- Gate
  - 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

Event 10: Walking Robot

- 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/ImVQ2tmS1O8 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)