

SkillsUSA

2010 Contest Projects

Mobile Robotics Technology

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2010 SKILLS USA CHAMPIONSHIP

MOBILE ROBOTICS COMPETITION Secondary

TEAM GUIDE

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Acknowledgments

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intelitek Inc.
AZTECH Educational Resources
Caterpillar
Holmquist Educational
Solidworks
IFI

Mobile Robotics Technical Committee

The following individuals contributed their time and energy to the Technical Committee.

Secondary Competition

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Judges

The following individuals contributed their time and energy as Judges for the competition.

National Educational Technical Committee

The following individuals contributed their time and energy to the National Educational Technical Committee.

Dr. Jeanea Lambeth Engineering Teacher
Camelback High School, Phoenix, AZ

Martin Bencic, Engineering Teacher
Sunrise Mountain High School, Peoria, AZ

Awards

The following companies have supplied awards:

intelitek

Solidworks

1: Contest Overview

Cutting-edge Technology

Many believe that in the future, robotics will encompass every part of life. Even today, robots do the jobs that people find dull, dirty or dangerous. To compete in this evolving field, companies will be looking for individuals who are fluent in mechanical design, electrical systems and robot programming. Additionally, working well in a team with diverse skills is important to success in the robotics industry. With today's complex design and engineering challenges, no individual is equipped with all the answers to any robotics problem.

Your Team

Success in a Mobile Robotics Competition is often found using a team approach. In the interest of emulating industry, this competition will be structured in this manner. For optimum team efficiency, we suggest your team be comprised of a specialist in each of the following fields:

- Mechanical Design
- Mobile Robotics Programming

1.1: Statement of the Problem

1.1.1: The Client's Needs

The Springfield Nuclear Power Plant (hereafter referred to as the client) is looking to improve on its nuclear waste disposal process. Normally, the client has to send highly trained workers into dangerous locations to move nuclear waste by hand to local containment facilities and to flatbed trucks to be disposed of off-site. This job is highly dangerous and could expose the employees to high doses of radiation. Additionally, in order to maintain a safe working environment, the waste is disposed of very slowly. Overall, this process is very costly and dangerous.

1.1.2: Your Assignment

As a Mobile Robotics development team, known as MD Robotics, your task is to create a mobile robot that can handle the nuclear waste and safely dispose of it in a timely fashion. This robot must be able to respond to operator commands on the fly, as well as autonomously collect and dispose of the nuclear waste.

The client's waste disposal facility is divided into two sections. One section is the collection facility where the waste is brought from the reactors and is treated to be safe to handle. The other section is the waste disbursement facility where the waste is processed and made ready for transport. Between these two sections, there is a thick, shielded wall designed to stop radiation from penetrating into the disbursement facility. A large portion of the door opens to allow workers to move the waste from section to section. However, the door is on an automatic timer that will close after sixty seconds to ensure that radiation does not leak out. Additionally, the collection facility's shielding does not allow a person to see in from the outside. This means that the robot will have to attempt to move waste to the disbursement facility completely autonomously.

1.2: Instructions

1.2.1: Initial Design

The Client is a nuclear power plant that needs a new robotic waste disposal system. Currently, the Client is able to give you a layout of the plant along with some general robot operating guidelines. The robot must autonomously deliver ten pieces of waste to the disbursement facility. Once at the disbursement facility, the robot will need to load the waste either into flatbed trucks or into local waste storage containers. Your team's job is to create a robot that can do these tasks.

The Client requires that each stage of the design fabrication, and programming process be well documented. This includes a bill of materials, assembly instructions, a code flowchart and a printed, final program for the robot.

After your prototype has been designed, programmed and assembled, you will test the robot in a simulation of the Client's facility.

1.2.2: Concurrent Engineering

The Client will review the prototype and may require one or more changes. Be prepared to handle waste that may be a different shape and size and handle the waste in different ways. Having a robot that can handle diverse challenges will make your design more appealing to the Client.

1.3: Guidelines

1.3.1: Requirements

The Client's Engineering Project Manager has provided an outline of materials to begin your planning and manufacturing process. Your success on this project is based upon the following criteria:

1. Teams must be composed of two members.
2. Teams are given a task that they will solve using a mobile robotic system provided by the technical committee.
3. During the orientation session, each team will have 10 minutes to present their Engineering Notebook to the judges.
4. Teams can only use an Engineering Notebook during the contest as a reference tool in the construction and programming of their robot.
5. The Engineering Notebook is a tool for students to document their designs prior to the competition. It can include pictures, printed out sections of code, detailed assembly instructions etc. All pages must be bound and numbered.
6. The Robot can only be constructed by the materials supplied by the technical committee.
7. Once a team has performed the required task or set of tasks, a design change may be introduced.
8. Contestants are required to adhere to industry safety standards using the hardware and software provided.

9. All team members are responsible for double-checking each other's work and quality control.
10. All engineering notebooks, forms, documentation and programs must be turned in to the judges at the end of the competition.
11. All team members and advisors are required to attend a debriefing session after the competition has concluded.

1.4: Kit of Parts

1.4.1: Kit of Parts Overview

Your robot may only be made of components listed on the Skills USA kit of parts. A full list is available in Appendix A

1.5: Team Guidelines

1.5.1: Challenge Rules

These are the official rules and guidelines for the Mobile Robotics Competition. All teams will be expected to adhere to these rules.

1.5.1.1: Definitions:

- Autonomous Period: A 60 second period in which robots operate only based on pre-programmed instructions and sensor inputs. Team members are not allowed to interact with the robot during this period.
- Driver Control Period: A sixty second period in which robots are operated by team members through a wireless transmitter.
- Autonomous Side: The right side of the field where robots begin the match.
- Operator Side: The left side of the field where all objects are scored.
- Green Ball: A four and one-half inch diameter, green foam ball.
- Short Goal: A bin approximately 18" long, 11" wide and 10" tall where green balls may be scored. The front opening of the goal is 9.25" wide and is 4" off of the ground.
- Tall Goal: An 18" tall goal located near the middle of the field where green balls may be scored.
- Scoring Zone: The volume defined by the inner edge of the field, or the outer edge of the short or tall goal and from the playing surface upwards infinitely.
- Penalty Starting Location: A tile where a robot will be placed if it is on the autonomous side of the field after autonomous, or if it would be contacted by the wall as it is replaced after autonomous. The zone is defined as the outside of an 18" by 18" taped box.

1.5.1.2: Field Setup

- The field is 12' by 12', enclosed by an 11.5" tall field border. The field is separated into two zones by an 11.25" tall wall.
- The surface of the field is grey, foam tiles.
- There are 20 green balls on the field. See Appendix B for the green ball layout.

- Two Short Goals begin the match two tiles up and two tiles in from each of the short edges of the field border on the operator side of the field.
- Two tall goals begin the match attached to the wall near the center of the field.
- The center section of the wall is removable. The match begins with this section of the wall removed. It will be replaced onto the field after the autonomous period to create a solid wall that robots will not be allowed to cross.

1.5.1.3: Scoring

- Points will be given out as follows:
 - Each green ball in the operator zone at the end of the match is worth one point.
 - Each green ball completely within a Small Goal at the end of a match is worth two points.
 - Each green ball in a tall goal at the end of a match is worth four points.
- A ball is considered scored if every part of the ball is within the scoring zone it would be scored in.
- Each ball may only be in one scoring zone at a time. When scores are tallied, a ball will always be in the scoring zone that is worth the most points.

1.5.1.4: Match Sequence

- 0-60 Seconds: Autonomous Period.
- 60 Seconds: The center section of the wall will be replaced. If a robot is still on the autonomous side of the field, or if it would be contacted by the wall as it is being replaced, the robot will be placed in the Penalty Starting Location.
- 60-120 Seconds: Operator Period.

1.5.1.5: Game Play Rules

- Each match will be two-minutes long and will consist of only one robot.
- Balls that leave the field during a match will not be returned to the field.
- During a match, robots may be remotely controlled only by the drivers and by software running on the control system. If any team member touches his or her team's robot anytime during a match, the robot will be disabled and the team disqualified from that match.
- Scores will be calculated once all robots and field elements come to rest.
- Robots must start the match touching the long edge of the field opposite the wall on the autonomous side of the field.
- Robots will begin the operator period in the operator zone in whatever orientation and position they end autonomous unless they have been placed in the penalty starting zone.
- Once the autonomous period is complete, the center section of the wall will be replaced. If a robot is on the autonomous side of the field or is touched by the wall as it is being replaced, that robot will begin the operator portion of the match in the penalty starting zone and will receive a ten (10) point deduction from their score. The robot must start the operator period touching the wall adjoining the penalty starting zone. Any balls within the robot will be removed from the field before the beginning of the operator period.

1.5.1.6: Robot Rules

- Robots must be no larger than 18" in every dimension at the start of a match. They may expand to any size once the match has begun.
- Robots may only be constructed from the same type and quantity of parts found in the Skills USA Vex Robot Kit, and only after the challenge has been released to teams.
- No robot may have mechanisms that could potentially damage the playing field or field elements, or pose a safety hazard to teams or spectators.
- All parts of the robot must remain attached to the robot for the duration of the match. Any infraction of this rule may result in an immediate disqualification. Minor pieces that unintentionally become detached from the robot, or are the result of improper design/construction will not cause a disqualification
- Teams may not modify any part of the control system or any motor or servo.
- Robots are allowed only the following non-Vex components:
 - Any material strictly used as a color filter for a Vex Light Sensor.
 - Any parts which are identical to legal Vex parts.
 - Any non-functional decorations that do not affect robot performance.
 - Commercial threadlocker may be used only to help secure fasteners.

1.5.2: Field Malfunctions

IN THE CASE OF A FIELD FAILURE: The team leader will communicate the problem to a representative of the Technical Committee. The representative will then notify the Project Manager. If it is determined that it is in fact a field problem, the match will be replayed. In the case of a replayed match, the previous score will not be counted and the team's rematch score will count, regardless of whether the team scores more or less points.

IN THE CASE OF PROGRAMMING PROBLEMS: A robot's program is the responsibility of the team. All software must be original copies. If your team develops a problem with your software or robot program, the Technical Committee will work in whatever way it can to resolve the problem but no matches will be replayed due to problems with the robot's program.

2: Official Competition

2.1: Purpose

2.1.1: Goals of the Competition

To evaluate each contestant's preparation for employment in fields related to mobile robotics and the team approach to problem solving in the work environment. To recognize outstanding students for excellence and professionalism in the field of mobile robotics.

2.2: Clothing Requirement

2.2.1: Correct Attire

For men: Official SkillsUSA white polo shirt with black dress slacks, black socks and black leather shoes.

For women: Official SkillsUSA white polo shirt with black dress slacks or skirt, black socks or black or skin-tone seamless hose, and black leather shoes.

All: Safety glasses with side shields or goggles. (Prescription glasses can be used only if they are equipped with side shields. If not, they must be covered with goggles.)

These regulations refer to clothing items that are pictured and described at: www.skillsusastore.org. If you have questions about clothing or other logo items, call 800-401-1560 or 703-956-3723. Note: Contestants must wear their official contest clothing to the contest orientation meeting.

2.3: Eligibility

2.3.1: Qualifications

Open to a team of two active SkillsUSA members enrolled in programs in a career and technical education engineering program or program that integrates robotics, engineering or pre-engineering techniques as an integral component of the instructional program.

2.4: Scope of Contest

The contest will test the ability to perform, exhibit and compile skills and knowledge from the following list of competencies determined by the SkillsUSA Mobile Robotic technical committee. Committee membership includes intelitek Inc., IFI and AZTECH Educational Resources.

Knowledge Performance

The contest will include a written exam assessing general knowledge of robotics operations and programming. Written portions may also exist during the skills portion of the contest.

Skill Performance

The contest will include activities that simulate situations encountered by robotic programmers and support professionals.

Contest Guidelines

1. Teams must be composed of two members.
2. Teams are given a task that they will solve using a mobile robotic system provided by the technical committee.
3. During the orientation session each team will have 10 minutes to present their Engineering Notebook to the judges.
4. Teams can only use an Engineering Notebook during the contest as a reference tool in the construction and programming of their robot
5. The Engineering Notebook is a tool for students to document their designs prior to the competition. It can include pictures, printed out sections of code, detailed assembly instructions etc. All pages must be bound and numbered.
6. Robot(s) can only be constructed by the materials supplied by the technical committee.
7. Once a team has preformed the required task or set of tasks, a design change may be introduced.
8. Contestants are required to adhere to industry safety standards using the hardware

2.4.1: Teams and Documentation

1. Teams **MUST** be composed of two members. Teams will demonstrate their ability to perform, utilize skills and knowledge necessary to complete the project as presented to them by the Technical Committee.
2. Your team is presented with a game challenge with which to design and prototype a robot. You will then be asked to assemble this robot at the event. When you finish the robot, you will participate in a number of matches. Your scores will be tallied and points will be awarded.. After your two matches, the game will be changed in some way, requiring you to modify some part of your robot.

2.4.2: Required Competencies

As defined by the technical committee.

2.5: Group Organizational Goal

2.5.1: Team Dynamics

The competition should run much like you would expect from industry; with group members interacting at will. The mechanical expert will lead in the robot construction while the programmer will lead the robot programming.

The contest is designed to promote creativity in organization of production responsibility. Teams should divide duties among all team members. No one individual should dominate by taking responsibility for more than one project specialty. When a team member has spare time, they will help their teammates. All Team members are responsible for double-checking each other's work and quality control.

2.5.2: Team Objectives

1. To have every team complete the competition.
2. To have each team member demonstrate reading and writing skills.
3. To have each team member use their critical thinking and problem solving abilities in the contest.
4. To have each team member illustrate responsibility, teamwork, self-management skills, and professionalism.

2.6: Engineering Notebook

2.6.1: Oral Presentation

Each team will have ten minutes to present their Engineering Notebook to the judges. Teams may bring additional support materials such as PowerPoint Presentations, posters etc. . A projector and screen will be available to all teams.

2.6.2: Parts of the Engineering Notebook

Note: All of the following items will be submitted for judging prior to the assembly portion of the event.

Completed Notebook (50 Points Available):

The Engineering Notebook will be judged on format, organization, and presentation.

Bill of Materials (50 Points Available):

Each team will be required to list all of the materials used on their robot, both in type and quantity.

Assembly Instructions (50 Points Available):

Teams are encouraged to create detailed assembly instructions for their robot prior to arriving at the competition.

Illustrations of Design Process (50 Points Available):

Teams are encouraged to include pictures and sketches of their design process in their Engineering Notebook.

Program Flow Chart (50 Points Available):

Teams are encouraged to include a flow-chart of their robots program in their Engineering Notebook. This chart does not require actual portions of code, but should be a general overview of how the program flows.

Printed Program for Robot (50 Points Available):

Teams should print their code and include it in the engineering notebook. This program should follow the team's flow-chart. This does not need to be the final robot program; however teams are encouraged to make their program as complete as possible ahead of time to maximize their score.

2.7: Required Materials

2.7.1: Workstation Components

Teams require the following materials to complete the competition. The Technical Committee provides many of these materials, but the teams must also bring certain items.

The Technical Committee provides:

1. Workspace for teams to cut materials, including a few small vises.
2. The competition game field and game materials.
3. A projector and screen for team presentations.
4. SkillsUSA Kit of Parts
5. A printer.

2.7.2: Team Provided Components

Teams will provide the following:

1. Safety glasses for each team member.
2. Rotary tool with appropriate attachments.
3. Allen wrench set.
4. Straight cutting tin snips.
5. A Vex Programming Cable.
6. A laptop with licensed Vex programming software.
7. A power strip.
8. (3) 7.2v Vex Robot Batteries
9. (3) 9.6v Vex Transmitter Batteries
10. (3) Vex Battery Chargers
11. A tape measure.

Note: ONLY the above listed items will be allowed in the contest area during the competition.

3: Safety

3.1: Importance of Safety

To maintain an effective and competitive company, it is in the best interest of both employer and employee to maintain a safe work environment. When a company's history of incidents resulting in injury is minimal, the company increases its likelihood of reduced insurance rates and workman compensation fees.

Safety considerations are taken into account during judging to further replicate a professional industrial environment.

3.2: Safety Violations

If a team or a team member violates a safety rule, or operates their robot in an unsafe manner, the following penalties will be enforced:

1st Violation:

Team will be issued a written warning.

2nd Violation

Team will have 50 points deducted from their total score.

3rd Violation

Team will be disqualified.

3.3: Avoiding Safety Hazards

Some safety issues:

1. Team members must keep their work area reasonably clean. Clean work places promote efficient and safe working conditions.
2. Team members must keep their teammates and other teams aware of possible dangerous situations, such as pinch points, sharp edges and the enabling of robots.
3. Team members must wear safety glasses when they on the playing field and while they are in their work area.
4. Tampering with or dismantling of any part of the supporting equipment (ie: computers, printers, ect.) is a direct safety violation, and can be grounds for immediate disqualification.

4: Additional Forms

4.1: Document Submission

The following documentation must be prepared by teams for judging.

- Engineering Notebook
- Math Problem

SKILLS USA
Mobile Robotics
 JUDGING FORM 2010

	MAXIMUM POINTS	CHECK	POINTS AWARDED
Presentation			
1. Oral Presentation	50		
2. Presentation Support Materials	50		
Presentation Subtotal	100		
Engineering Notebook			
1. Completed Notebook	50		
2. Bill of Materials	50		
3. Assembly Instructions	50		
4. Illustrations of Design Process	50		
5. Program Flow Chart	50		
6. Printed Program for Robot	50		
Engineering Notebook Subtotal	300		
Robotic Task Performance			
1. Round one and two Score	300		
Robotic Task Performance Subtotal	300		
Concurrent Engineering			
1. Round three and four Score	150		
2. Area Clean-Up	50		
Concurrent Engineering Subtotal	200		
Math Problem	100		
Safety (deductions)			
GRAND TOTAL	<u>1000 pts</u>		

Appendix A – SkillsUSA Vex Robotics Kit Bill of Materials

Item	Quantity
3-Wire Motor	5
3-Wire Servo	1
PIC Microcontroller V0.5	1
Line Tracking Sensor	3
Quadrature Encoder	2
Ultrasonic Sensor	1
Potentiometer	2
Clutch	6
5" Wheel	4
4" Wheel	4
2.75" Wheel	4
Intake Roller	4
Double Bogie wheel assemblies	4
Single Bogie wheel assemblies	2
Tank tread drive/idler wheels	4
Tread Links	170
10-tooth sprockets	2
15-tooth sprockets	4
24-tooth sprockets	4
40-tooth sprockets	2
48-tooth sprockets	2
Chain Links (48")	326
Differential frame	1
12-tooth pinion gear	2
12-tooth gears	8
19-tooth rack gear	12
Worm wheel	4
24-tooth bevel gear	7
36-tooth gears	8
60-tooth gears	10
84-tooth gears	4
Worm gears	4
Bearing Flat	46
Bearing Pop Rivet	100
Pillow Block	6
Lock Bar	4
Shaft Collar	37

12" Shaft	4
2" Shaft	8
3" Shaft	10
4" Shaft	3
11mm Shaft	11
Chassis Bumper (15-hole)	2
Chassis Bumper (25-hole)	2
Chassis Rail (16-hole)	4
Chassis Rail (25-hole)	4
C-Channel, 1x2x1x15 hole	4
C-Channel, 1x2x1x25 hole	3
C-Channel, 1x5x1x25 hole	2
Segmented Angle, 25-hole	2
Slotted Angle, 30-hole	2
Slotted Angle, 30-hole, REVERSE	2
Bar, 25-hole	10
Plate, 5 x 15 hole	3
Plate, 5 x 25 hole	2
Plate, 5 x 5 hole	2
Angle Gussets	4
Pivot Gussets	4
Plus Gussets	4
1" Standoffs	12
1/2" Standoffs	14
2" Standoffs	8
3" Standoffs	8
Screw, 6-32 x 1/2" Long	18
Screw, 6-32 x 1/4" Long	34
Screw, 8-32 x 1/2" Long	38
Screw, 8-32 x 1/4" Long	120
Screw, 8-32 x 3/4" Long	16
Screw, 8-32 x 3/8" Long	51
Screw, 8-32 x 1" for Bogie wheels	12
Nut, 8-32 Keps	181
Nut, 8-32 Nylock	28
Spacer (8mm)	21
Spacer (4.6mm)	31
Plastic Washer	10

Steel Washer	30
4" Zip Tie	100
7.2v Robot Battery + Charger	1
9.6v Transmitter Battery + Charger	1
VEX Battery Holder (7.2V - AA 6x)	1
Cable, VEX "Y"	2
Cable, 3-Wire Extension, 6"	2
Cable, 3-Wire Extension, 12"	3
Cable, 3-Wire Extension, 24"	1

Cable, 3-Wire Extension, 36"	1
Tool, Allen Wrench Large (3/32")	1
Tool, Allen Wrench Small (5/64")	1
Tool, Nut Starter	1
Tool, VEX Open-Ended Wrench	1
Bumper Switch	2
Limit Switch	2
75 MHz Transmitter and Receiver	1
Jumpers	5

Appendix B – Field Information

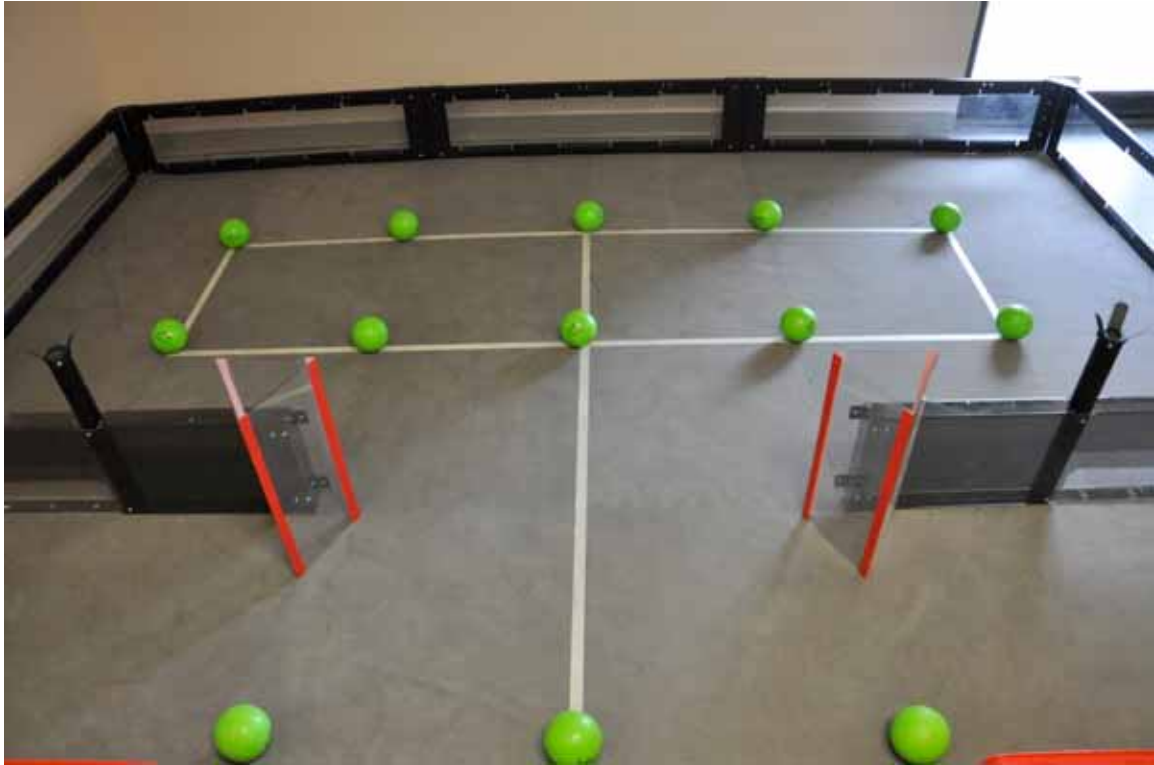
Field Pictures



Full Field View – Gate open



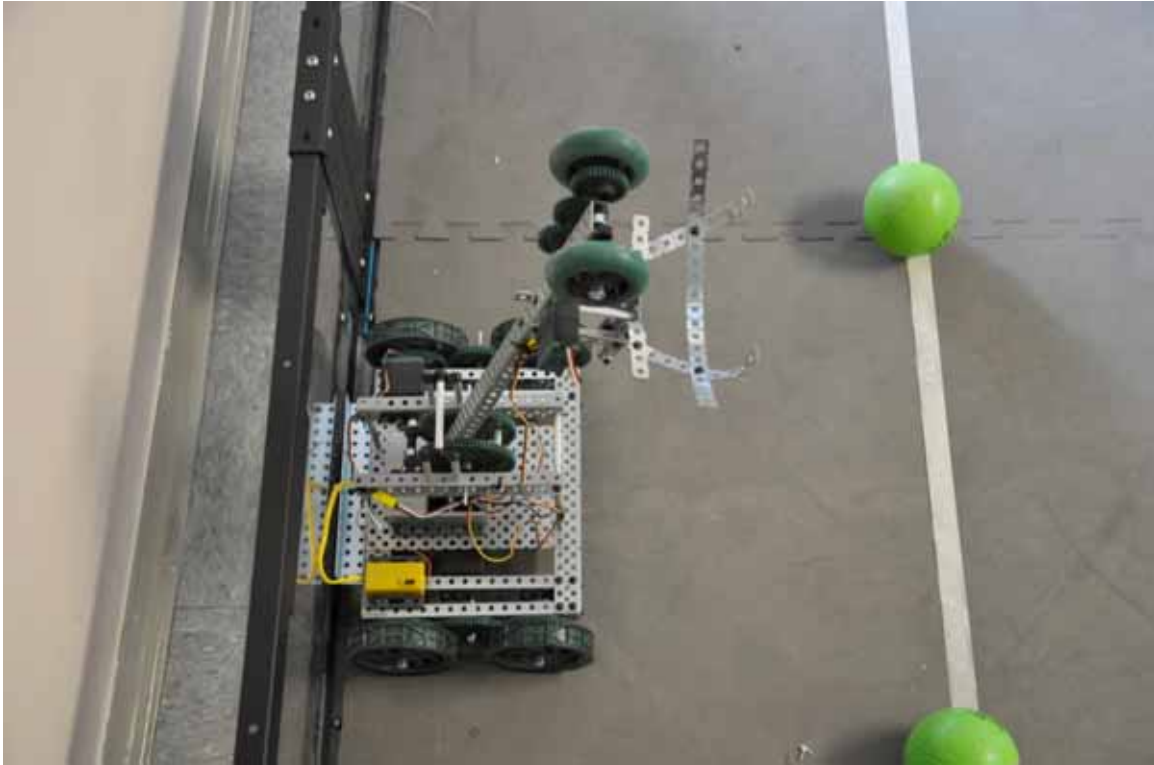
Full Field View – Gate Closed



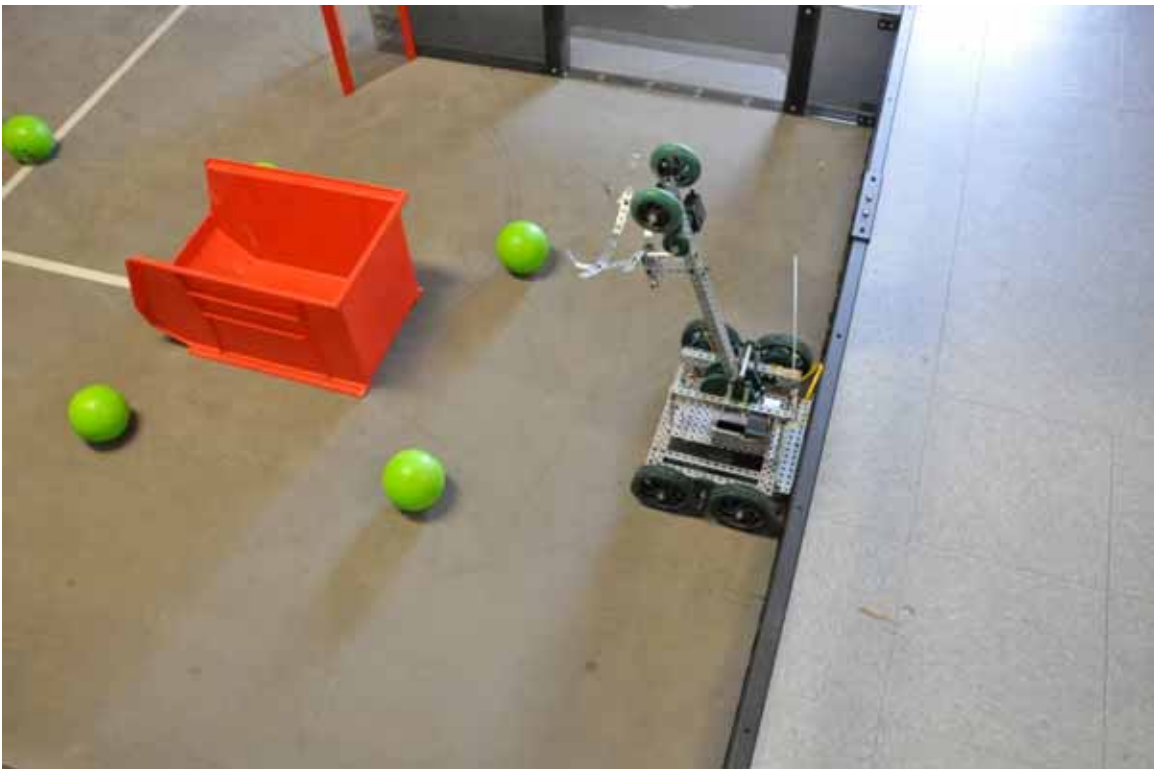
Autonomous Side



Operator Side

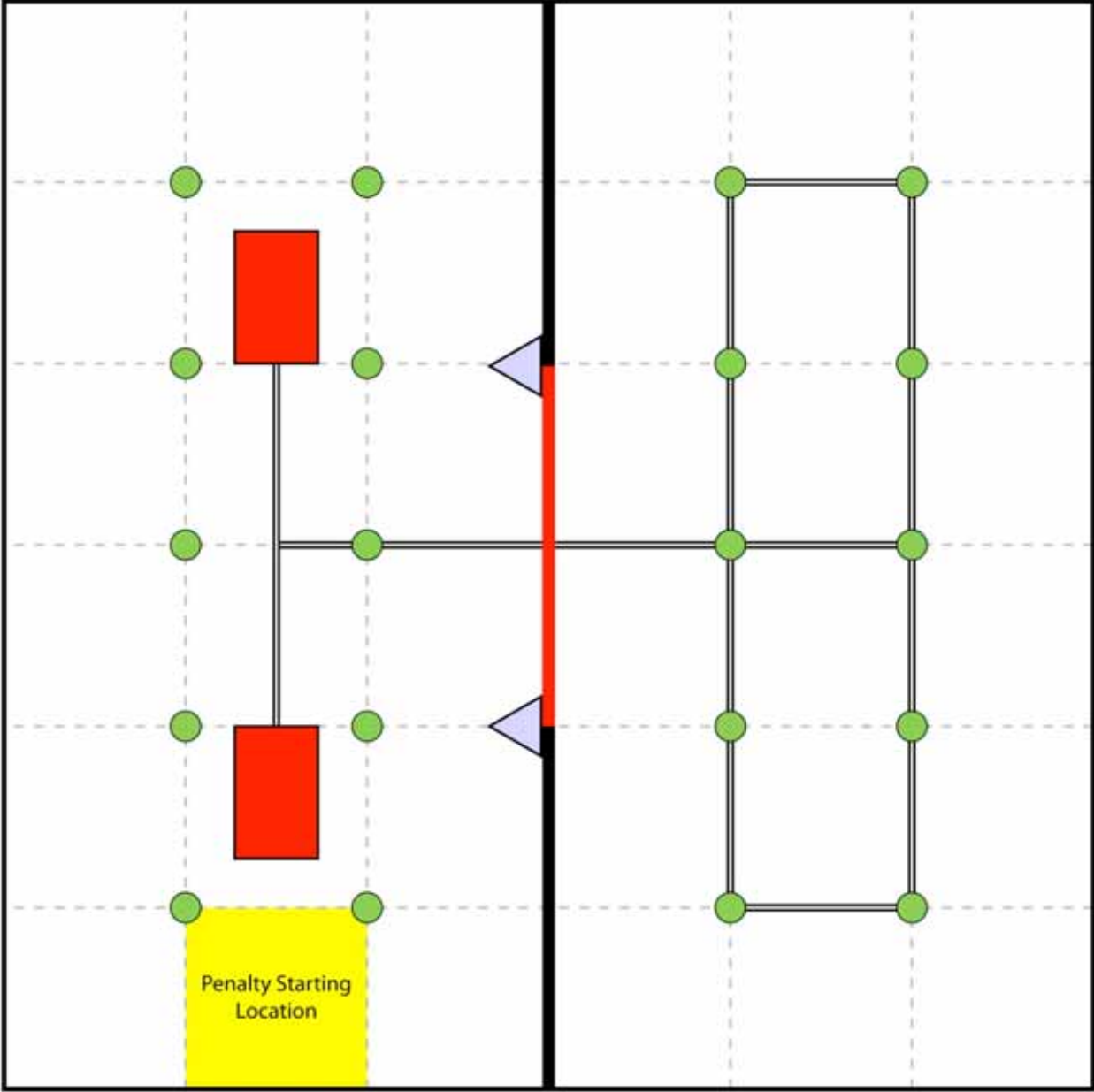


Robot in the correct starting position

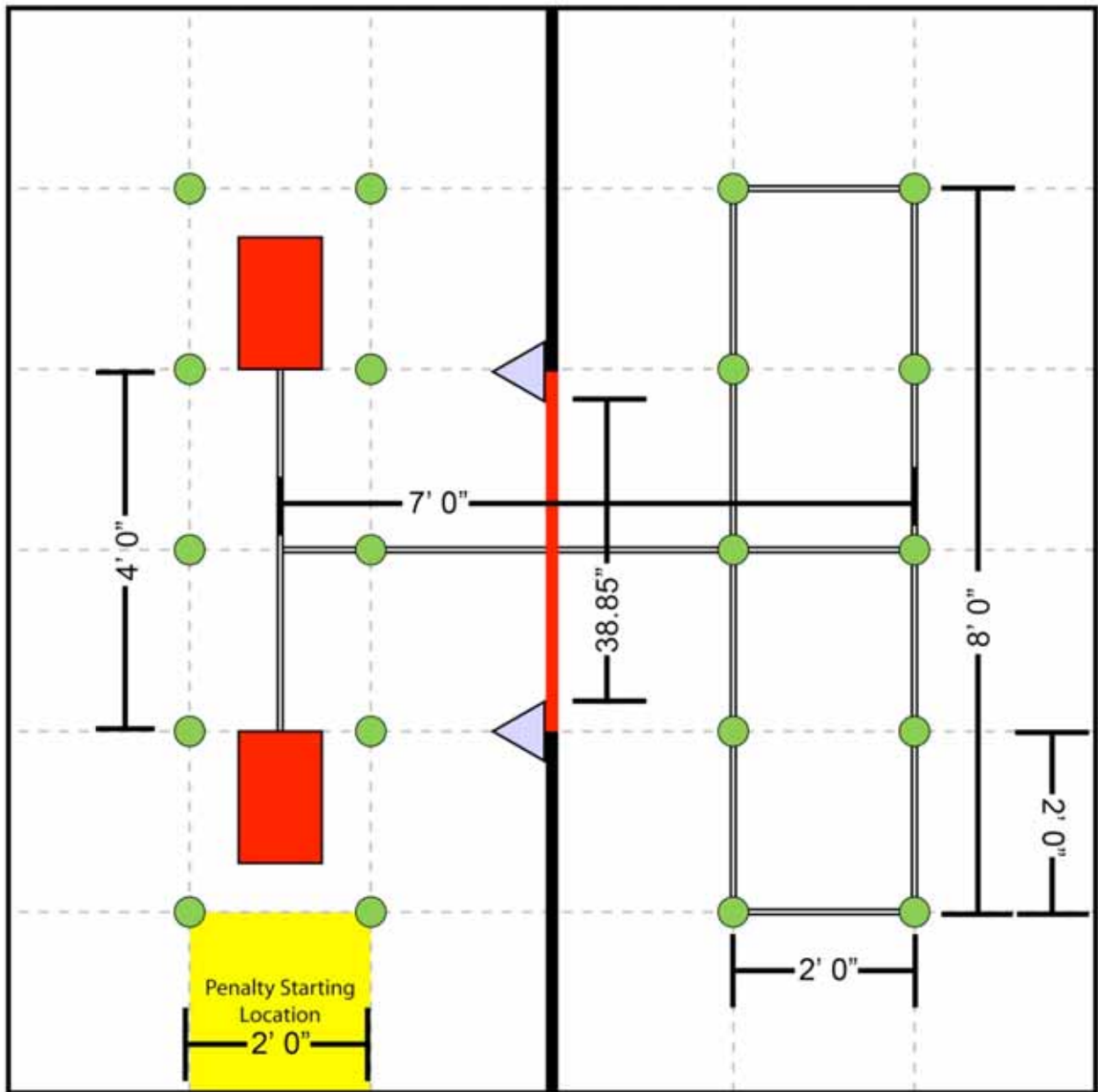


Robot in correct penalty starting location

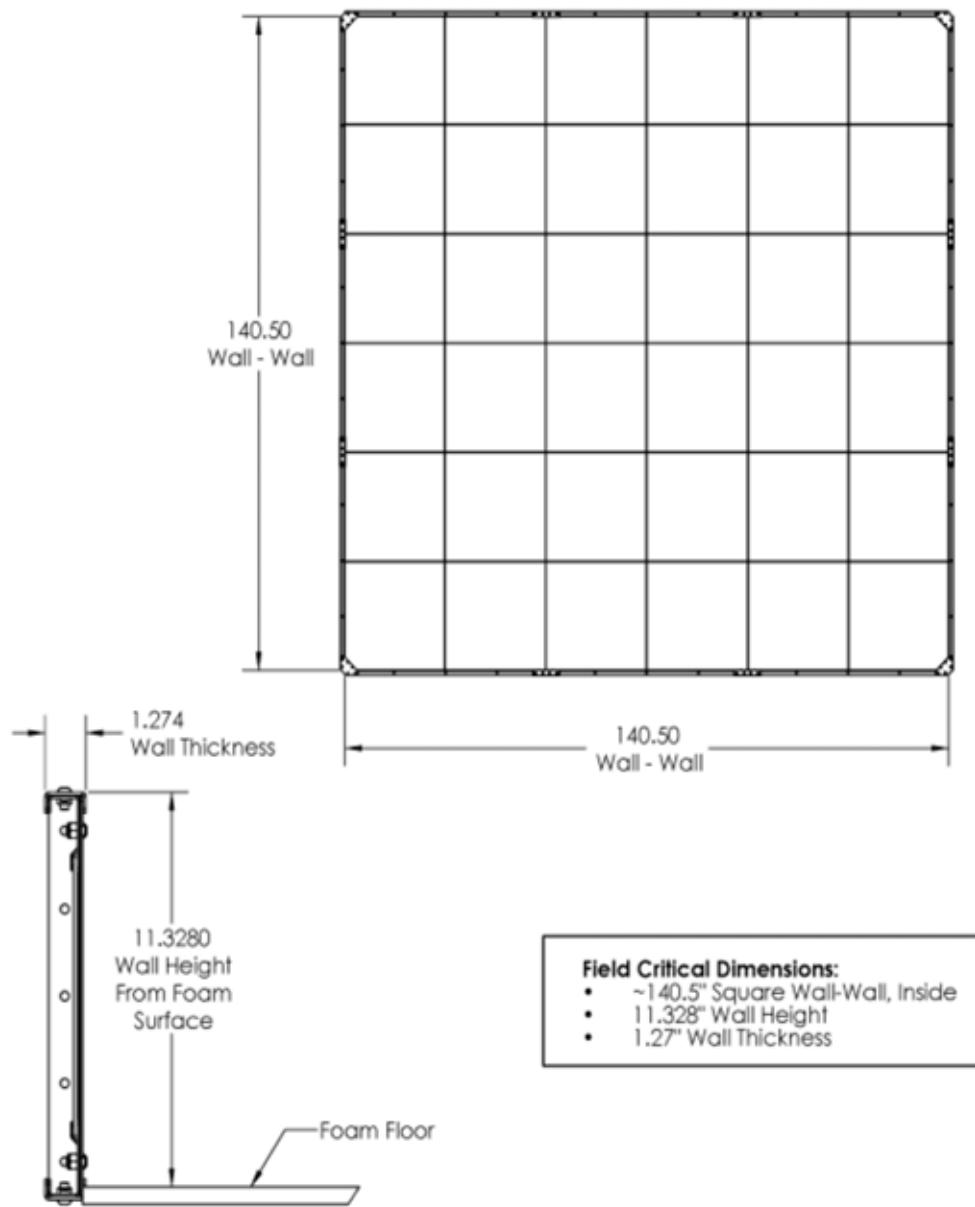
Field Diagrams



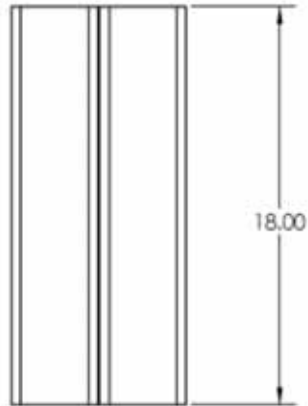
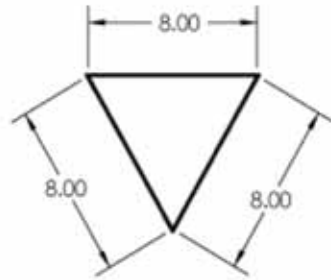
Full field diagram



Full field diagram with dimensions



Playing surface and field border



Large goal

Game Pieces

Green ball

Green balls are approximately four inches in diameter and are made of polyurethane foam, similar to a “Nerf” ball. A green ball weighs approximately 0.125 lbs. To purchase this item, please go to <http://www.vexrobotics.com/products/competition-products/275-1399.html>.

Small Goal

The small goal is a red bin available from Uline (part number S-12421R). The goal is approximately 18” long, 11” wide and 10” tall. The front opening of the goal is 9.25” wide and is 4” off of the ground. To purchase this item, please go to <http://www.uline.com/Product/Detail/S-12421R/Plastic-Bins/18-x-11-x-10-Red-Plastic-Stackable-Bins>.