Hardware Competition Rules

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2021 SoutheastCon Hardware Competition Rules
"Engineers Connecting the World"

1. Introduction

Everyone's favorite classic arcade game is coming to IEEE SoutheastCon 2021! Earn points by navigating the maze, collecting pellets, and avoiding ghosts. Acquire the correct Power Pellet to turn the tables and chase down ghosts for the highest score!

2. Objective

Develop a robot to autonomously navigate the maze, collecting pellets, and avoiding ghosts until it has acquired the correct Power Pellet. The score is determined by 1) the number/type of pellets collected, 2) avoidance/contact with ghosts, and 3) the time it takes for your robot to return to Home Base. A robotic version of the classic game takes chomping, avoiding, and chasing through real mazes to a whole new level!

3. Competition

Your robot will have **five** minutes to autonomously navigate the maze while collecting pellets and avoiding or chasing ghosts. Below is a detailed competition flow:

- Each team must select a Proctor, without conflict of interest, to act as a witness. They must be registered in advance using the Witness Agreement form.
- All teams will play a qualifying match of competition.
- The qualifying match will consist of three sets of gameplay.
- Each set is five minutes long.
- A set timer begins when the start command is given and ends when a buzzer sounds, signaling the end of a set.
- The competition will have multiple sets of competition occurring concurrently until every team has completed the qualifying match.
- The teams with the four highest cumulative scores during the qualifying match will be announced as the Top Four.
- The Top Four teams will participate in a final match of competition.
- Scores will reset for the final match of competition.
- The final match of competition will be held on Saturday night **during** the awards banquet.
- The final match of competition will consist of four sets of gameplay.
- The team with the highest cumulative score during the final match will be declared the SoutheastCon 2021 Hardware Competition Winner.

4. Game Format

The competition will be conducted synchronously online via live stream. A proctor and robot handler must be physically present to conduct gameplay. It is composed of navigating the game board maze while avoiding the ghosts until you have collected the correct Power Pellet. Upon collecting the correct Power Pellet and touching the matching stationary ghost, you may then chase ghosts.

a. Objectives

i. Collect pellets

- Collect magnetic and non-magnetic pellets that are distributed throughout the game board in the areas A, B, C, D, E, F, and H.
    - All areas will contain at least one normal pellet, none will be empty.
- There are 17 total pellets on the game board (2 specials + 15 normal).
- There are 2 special pellets with different symbols, one circle and one triangle.
    - The designation of the Power Pellet will be announced during gameplay.
- There are 15 normal pellets (8 non-magnetic and 7 magnetic) of different colors.
    - Non-magnetic: 2 red, 3 green, and 3 blue.
    - Magnetic: 2 red, 2 green, and 3 blue.
- At the beginning of each set, there will be a distribution of:
    - **Ten** normal pellets (random assortment of magnetic / non-magnetic) in areas A, C, F, and H
        - *Areas A&C are grouped together as they are fully enclosed.*
        - *Areas F&H are grouped together as they are open.*
        - *Each team will experience one of each of the following percentage splits of the ten pellets:*
            - *50/50 split across areas A&C and F&H respectively.*
            - *30/70 split across areas A&C and F&H respectively.*
            - *70/30 split across areas A&C and F&H respectively.*
    - **Five** normal pellets (random assortment of magnetic / non-magnetic) in areas B, D, and E.
        - *Pellets are randomly distributed across all three areas.*
        - *No guarantees are made about the distribution.*
    - **Two** special pellets (Power / Poison Pellet), one each in areas A and C.

- Pellets are randomly distributed per the general limitations above and their orientation is limited by the following:
  - Pellets will **not** be stacked on top of each other.
  - Pellets are **not** guaranteed to be any given distance from each other nor the interior and exterior maze walls.
- Special Pellets locations will be randomized between areas A and C (one in each area) and their orientation is limited by the following:
  - At least one symbol will **not** be covered, by other pellets or otherwise.
  - Special Pellets will **not** be stood upright (always laying down on a broad face so as to not topple).
- Pellets must be returned to home base to receive points.
  - Pellets on-board the robot will be counted.
  - In order to score, pellets must be either visible and easily countable or quickly extracted for counting.
  - Penalties for disrupting gameplay may be given, if the removal of pellets from on-board the robot takes an excessive amount of time (prevents teardown and setup for the next set).

ii. Avoid Ghosts

- Avoid physical contact with the ghosts to prevent loss of points.
- Continue to avoid ghosts throughout the game until completion of power play phase.
- There are 2 total ghosts (stationary).
  - Stationary: Inky, Blinky (Red with circle or triangle symbols)
- At the beginning of each set, there will be a distribution of:
  - **Two** stationary ghosts distributed in areas G1, G2, G3, G4, or G5
    - Only one ghost per occupied area.
    - Impassible distributions are **not** possible:
      - G1 and G2 simultaneously
      - G3 and G4 simultaneously
    - G5 will only be occupied during one set per match.
- Stationary ghosts are randomly placed per the general limitations above and their orientation is limited by the following:
  - At least one symbol will **not** be covered.
  - Stationary ghosts will **not** be stood upright (always laying down on a broad face so as not to topple).
  - Stationary ghosts will be placed within the red bounding boxes on the board.

iii. Pick Up the Power Pellet & Avoid the Poison Pellet

- The Power Pellet and the Poison Pellet will be identified by the judges by location (Either area A or area C).
- Navigate to the Power Pellet. Avoid the Poison Pellet.
- Continue to avoid ghosts. Penalties will be taken until the matching ghost is captured.
- The location of the two Pellets must be verbally communicated to the robot within 30 seconds of the Power Pellet announcement at the beginning of a set.

iv. Capture the Correct Ghost

- After acquiring the Power Pellet, you may now capture the matching stationary ghost.
- Navigate to the stationary ghost whose symbol matches that of the collected Power Pellet.
- Completely push the matching stationary ghost outside the red bounding box.

v. Earn Bonus Points

- A Time Bonus can be earned:
  - After collecting the power pellet and collecting **all** remaining non-poison pellets, upon return to home base the set will end early.
  - 1-point bonus is awarded for every second remaining in the set.
- A Ghost Bonus can be earned:
  - After collecting the power pellet and the matching stationary ghost, upon contact with the remaining stationary ghost.
  - 100-point bonus is awarded for each ghost.

b. Phases

i. Setup and Start

- The proctor must be present during each competition round. They should join the stream as their own user with a camera for any discussion necessary.
- The robot handler should join the stream as their own user with a camera for viewing gameplay. The camera view must show the entirety of the game board.
- Teams are called for qualification and standby. One-minute window to arrive.
- Objects are placed on the game board by the proctor.
- Robot is in standby in camera view.
- Robot is placed on the home base.
- 30 second setup period, handler may adjust switches and buttons as necessary.
- Contest officials will give a verbal start command.
- The robot handler must then manually start the robot by pressing a button or flipping a switch on the top of the robot.
- No further physical interaction, hands off, between the robot and people present is allowed during the set.
- The robot must run autonomously without any communication.
  - *Illegal communication with the robot, such as wireless communication, visual communication, or auditory communication outside of the Setup and Communication Phase will result in automatic disqualification.*

ii. Communication / Special Pellets

- Communication phase begins immediately after setup and hands off begins.
- Judges reveal the location of the Power Pellet by showing a sign on camera displaying an **A** or a **C** denoting the location on the game board.
- The pellet in the other location is now the Poison Pellet.
- The robot handler must audibly communicate the location of the Power Pellet with the robot, within 30 seconds of its announcement.
  - *The room and environment will be remote and therefor ambient noise level cannot be controlled by the judges.*
- The team may choose to communicate additional information to the robot during this phase, as long as it is auditory.
- The robot may start the next phase of its mission whenever it is ready.

iii. Pellet Collection

- Collect regular pellets (magnetic and non-magnetic) while navigating to the Power Pellet in location **A** or **C**.
- In this phase, touching ghosts will result in penalty.

iv. Power Play

- Power Play phase starts when the correct Power Pellet is collected.
- Power Play phase ends when the matching Stationary Ghost is captured.
- The robot navigates to the corresponding stationary ghost whose symbol matches the collected Power Pellet.
- Make contact with the corresponding stationary ghost to gain power.
- Push the stationary ghost with the corresponding symbol completely outside of the red bounding box.
- Make contact with the remaining stationary ghost to earn bonus points.
- Continue to collect regular pellets for more points.
- After collecting all non-poison pellets, return to Home Base to earn time bonus points.
- The Power Play phase lasts until the end of the set if not completed by capturing the matching stationary ghost.

5. Game Board

The game board is constructed with materials from any hardware store. Students are in charge of making a game board along with all the components. A diagram, with measurements, of the game board is shown on the next page in Figure 1. Components are screwed together using 1-1/4" long #6 wood screws. Further details about the Game Board are described in Appendix A – Game Board and Objects Specifications. Details regarding paints are described in Appendix B – Building Material Recommendation, details regarding construction are described in Appendix C – Construction Recommendations, and a parts list is shown in Append D. – Parts List.

The game board is a single 4' x 8' sheet of smooth sanded plywood, surrounded by 2" x 3" wood stud lumber (the actual nominal dimension is 1.5" x 2.5") that forms the frame around the plywood.

1. The plywood will be divided into a maze with different bases to navigate.
2. Internal maze walls are constructed using 2" x 3" wood stud lumber (the actual nominal dimension is 1.5" x 2.5").
3. All walls will be secured to the plywood using 1-1/4" #6 wood screws (48 total).
4. Screws are inserted from underneath the plywood into the stud walls.
5. All screws will be counter-sunk and leveled with the wood surface.
6. All corners will have screws inserted from stud to stud (29 total).
7. All inner walls will be attached to outer walls from the outside of the game board.
   a. These holes will remain untreated
8. All joints between inner walls will be treated such that they will be smooth
   a. Wood filled, sanded, and then painted over
9. **Start Square:** Starting position of the robot. 7" square corresponding to the size restrictions of the robot.
10. **Home Base:** 11" radius half circle centered and aligned against the bottom wall.
11. **Areas A & C:** Location of the Power Pellet and the Poison Pellet. The judges will communicate the location of the Power Pellet by a card with the letter **A** or the letter **C**. The other pellet is now the poison pellet. Normal pellets will also be in these areas (no area may be empty of normal pellets).
12. **Areas B. D, E, F, H:** Locations of normal pellets.
13. **G1, G2, G3, G4, G5:** Potential locations of the stationary ghosts, Inky and Blinky. The actual location will be chosen by a random number generator. *Please note:* G1 and G2 will not be selected simultaneously. G3 and G4 will not be selected simultaneously. G5 will only be experienced in 1 set of a match. All other combinations are possible.
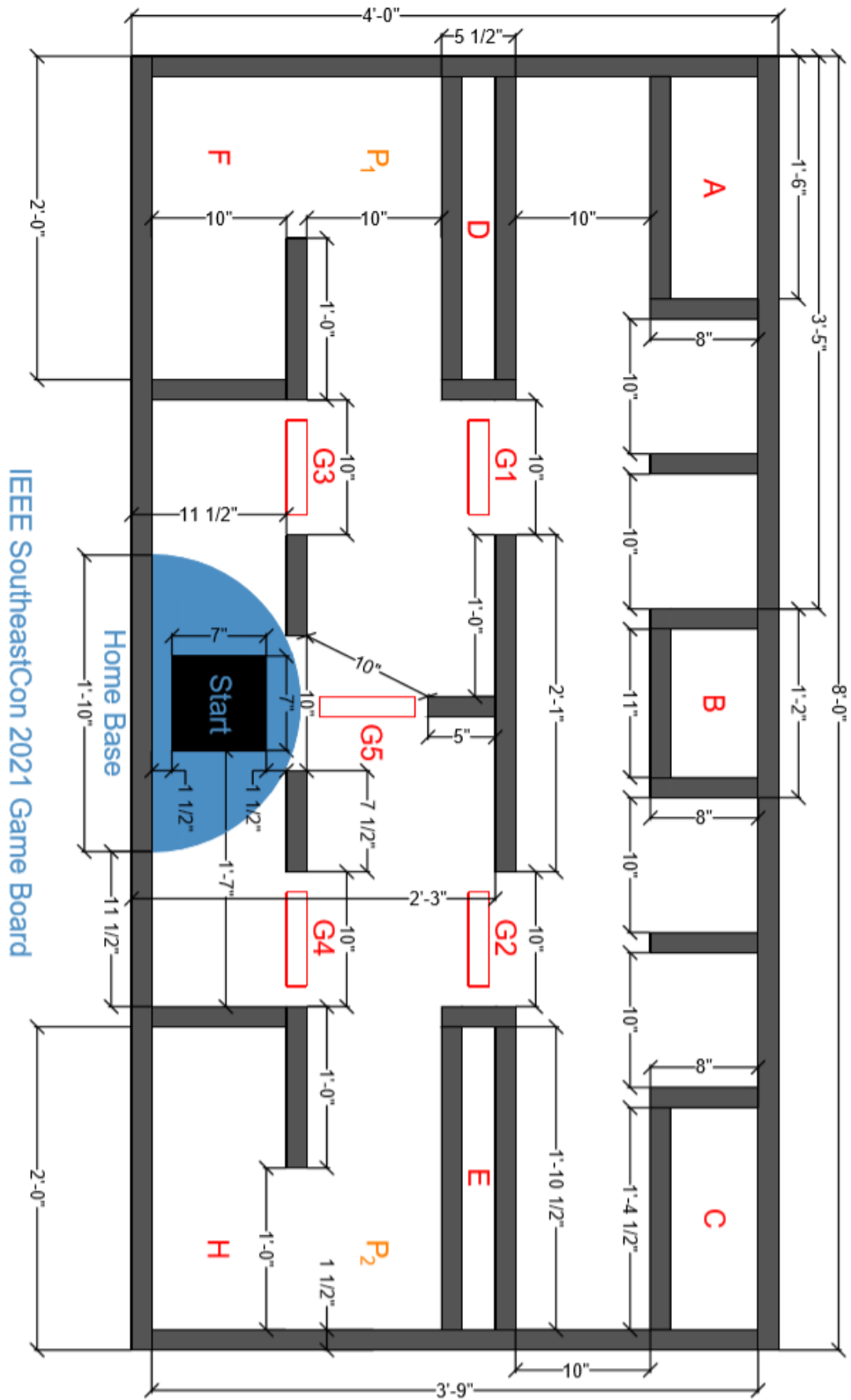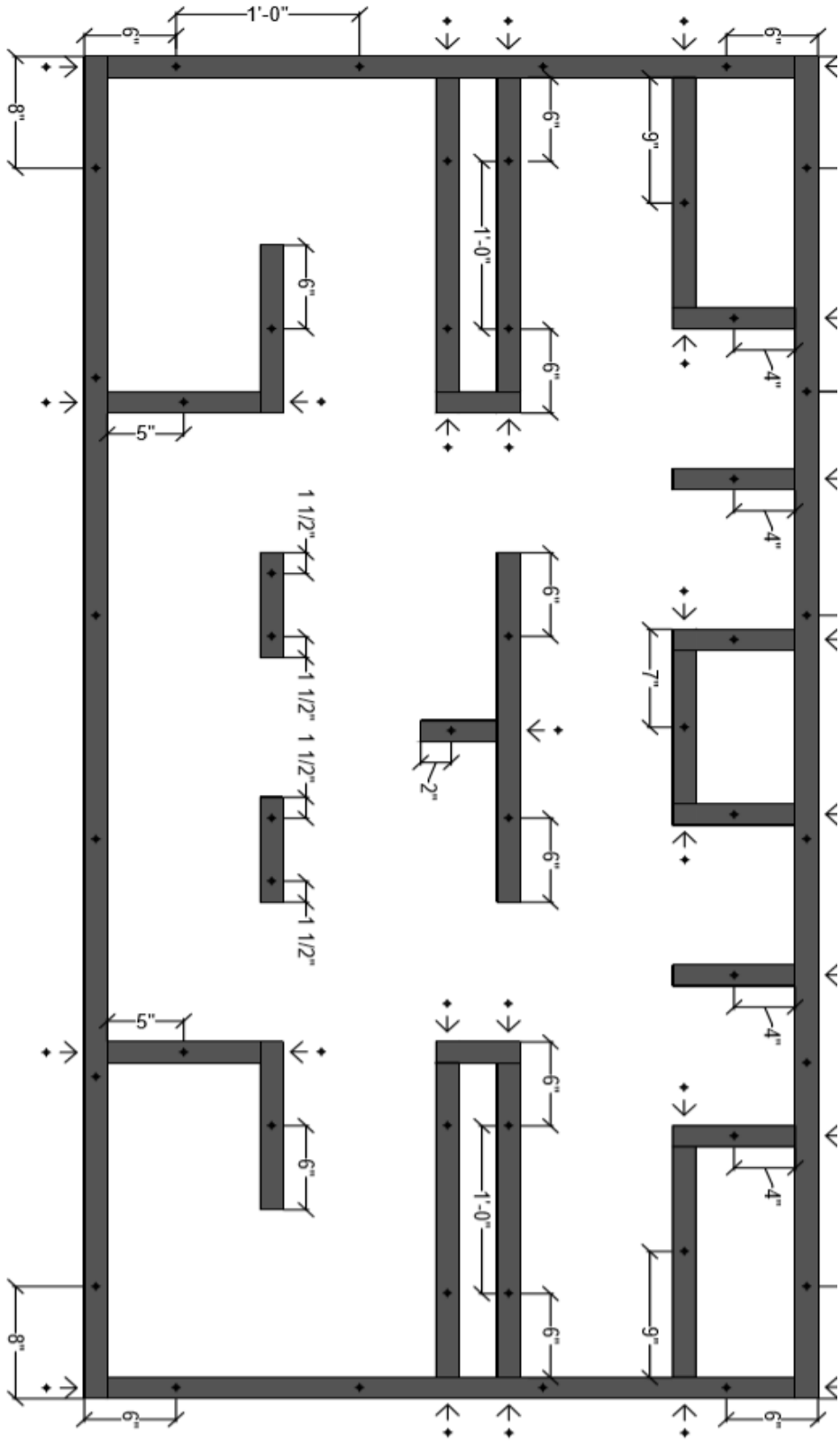
Figure 1 - Game Board

Figure 2 - Game Board, Locations of all screws
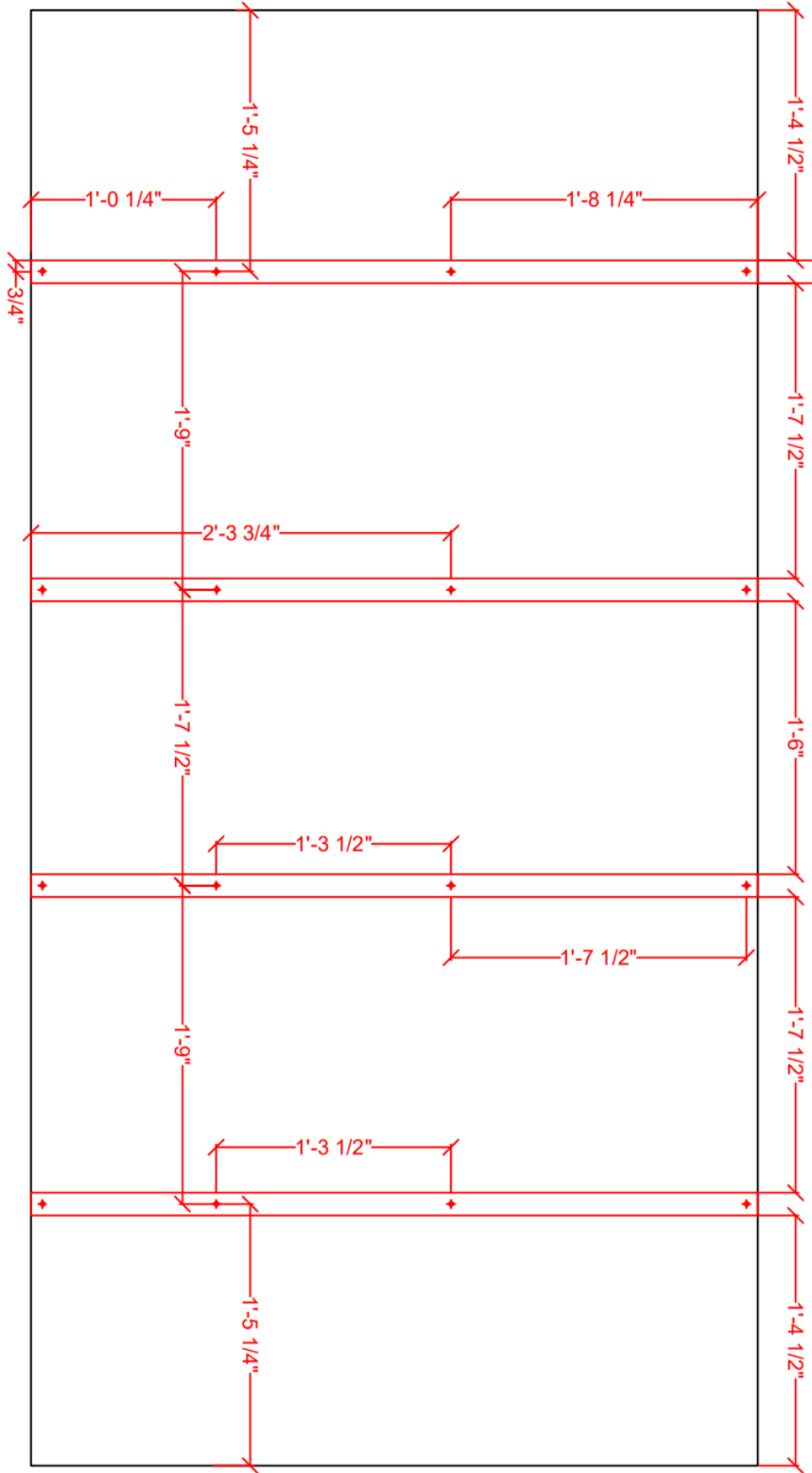
Figure 3 - Game Board Underside

Normal Pellet
1-1/2" x 1-1/2" x 2-1/2"

Non-Magnetic

Magnetic

22 Gauge Sheet Metal
1" x 1"
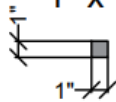
Power Pellet
3-1/2" x 1-1/2" x 2-1/2"
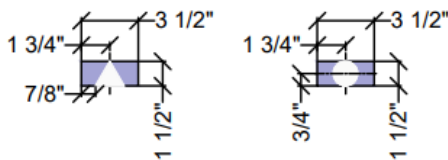
Stationary Ghost
6" x 1-1/2" x 2-1/2"
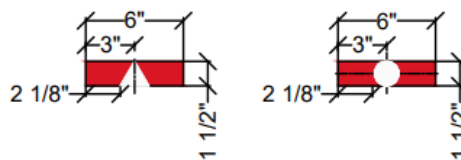
Symbols: 1-1/2"h Stickers, Centered
On Both Broad Faces

Figure 4 - Game Objects

Power Pellet
3-1/2" x 1-1/2" x 2-1/2"
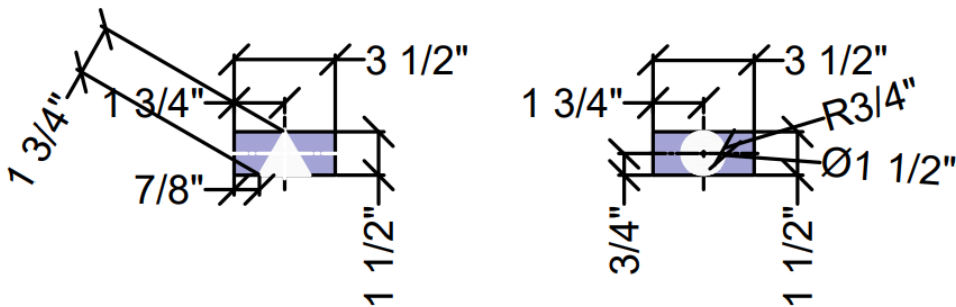
Figure 5 - Power Pellet Detail

Stationary Ghost
6" x 1-1/2" x 2-1/2"
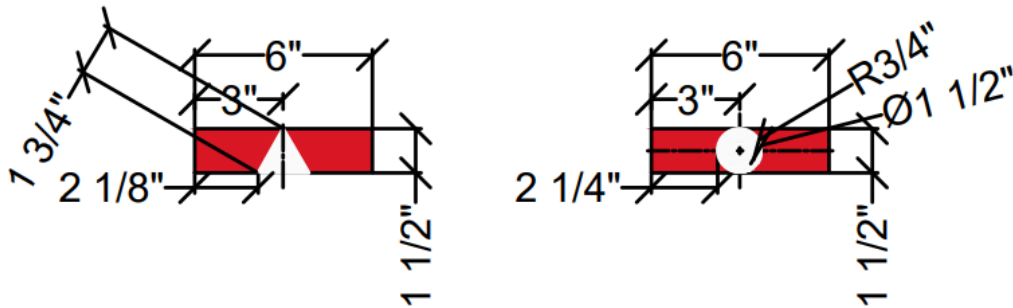
Figure 6 - Stationary Ghost Detail

An AutoCAD model of the game board is available in discord. If you are unable to open Autodesk files natively, you may view the model in the online viewer tool.

https://autode.sk/2IRHuuj

This viewer has a tool to measure distances within the model so that you may double check dimensions. Note, link may not contain latest released model, see discord.

6. Robot Specification Rules

1. Robots must operate completely autonomously once started.
2. Robots must be self-contained and remain a single unit, e.g. cannot break apart.
3. No wired or wireless communication is allowed.
4. Auditory communication is the only allowed means of transmission of information from the team to the robot.
5. The maximum size of the robot will be restricted to 7" x 7" x 7".
6. A robot may extend an arm after starting, a maximal distance of 9" from the side that an arm extends from. The tolerance will be 0.25" in every dimension.
7. The robot must not exceed a weight of 50 lbs.
8. Robots must have clearly labeled ON switch.
9. Robots must be wholly contained within playing surface (must not overhang).
10. No aerial or flying robots allowed.
11. No explosive, pyrotechnic, toxic or corrosive materials. Flammable liquids or gases are prohibited.
12. Tethering or external control of the robot is prohibited and will result in immediate **disqualification** from the competition as a whole.
13. It is recommended that the robot have an easily reachable Emergency Stop mechanism / button / switch.
14. It is encouraged for the robot to display a school flag or logo, state, territory, or national flag. The flag must fit within the initial size constraints of the robot. The flag can be static, or can be raised automatically at any time once the match begins.
15. **Teams are responsible for the safety of their robot. With the game board being raised, teams should take extra precaution to avoid the robot falling off the game board as no modifications including padding will be allowed to or around the game board and floor. In case of such falling instance, the team will automatically end the competition set and scoring will be up to that point.**
16. **The robot shall not present any danger to the judges, spectators, playing arena, or area surrounding the arena. If at any time the judges deem the robot is causing or is likely to cause harm, the judge may terminate the match immediately. The judge will have the discretion of whether any points are awarded for that match and if the robot is allowed to compete in any remaining sets.**

7. Gameplay Rules

1. Timeslots will be assigned to each team in advance. These timeslots will be announced a week ahead of the conference dates. Teams may inform the committee of conflicts in private.
2. Prior to the beginning of each set, the next team(s) to play will be announced.
3. The announced team(s) must present their robots for qualification within one minute of their announcement.
4. Missing the qualification announcement window will result in disqualification of the missing team(s) from that set.
5. During qualification:
   a. The robot must fit inside a box with inner dimensions of 7" x 7" x 7"
   b. Any extensions will be measured at this time.
   c. The maximal extension of each arm will be measured to be within 9" from the side that an arm extends from.
      i. The tolerance will be 0.25" in every dimension.
      ii. The outermost shell of the bot is the reference point.
   d. The start button and failsafe button must be specified.
6. The announced team(s) robot must, following qualification, remain on standby sequester while the current set is underway.
7. Teams are encouraged to watch gameplay as spectators to support each other.
8. Teams are encouraged to have at least a "driver" or "handler" be present during their standby sequester period.
9. Team members are not allowed to enter the playing field or touch their robot until the five-minute set ends or a team decides to terminate its participation.
10. There is only one Power Play phase per set. The Power Play does not re-activate after second contact with the Power Pellet.
11. During the Power Play phase, each ghost can only be captured once per set.
12. Contact with targeted ghosts during the Power Play Phase will not result in an increase or decrease in points. If there is contact between the robot and a ghost, the ghost stays wherever it is. The robot will **not** get penalized again (immune).
13. If the Power Play is successful, there is no penalty for touching or bumping of ghosts.
14. If the power play is unsuccessful, penalties will be given for bumping or touching of ghosts, but **no double** penalties (immune).
15. Robots must not damage the playing field, cause a halt of competition, or require repair of the playing field. Doing so will result in **disqualification** from the competition as a whole.

16. **Teams are responsible for the safety of their robot. With the game board being raised, teams should take extra precaution to avoid the robot falling off the game board as no modifications including padding will be allowed to or around the game board and floor. In case of such falling instance, the team will automatically end the competition set and scoring will be up to that point.**

17. **The robot shall not present any danger to the judges, spectators, playing arena, or area surrounding the arena. If at any time the judges deem the robot is causing or is likely to cause harm, the judge may terminate the match immediately. The judge will have the discretion of whether any points are awarded for that match and if the robot is allowed to compete in any remaining sets.**

18. When addressing judges with questions, teams are expected to act within the IEEE code of conduct. (Violation of the code of conduct will result in **disqualification** from the competition as a whole). Only one designated team captain can address the judges for written or verbal decision appeals.

19. Flash photography will **not** be allowed. On board lighting is allowed as long as the robot is not flashing nor interfering with operation of other robots on other game boards.

20. *Reasonable noise levels should be accounted for by teams during practice and competition. The room and environment will be remote and therefor ambient noise level cannot be controlled by the judges.*

21. In general, redo will not be allowed for fairness to all teams. However, judges reserve the right to make a call in the event of external interference, such as power outage, microphone feedback, and other reasonable issues in the field.

22. Every effort will be made to maintain courses between sets and matches, but in the interests of time minor scuffs (etc.) will not be addressed.

23. **All judges' / timekeepers' decisions are final.**

24. Judge's score sheets are **final**, score sheets returned to teams are for your reference only. Any point of dispute must be present on the **judge's score sheet** in order to be considered valid.

25. After each set, teams will have a 5-minute window (after their score is displayed) to file an appeal with the judges / timekeepers if they believe a scoring error exists. Teams should use caution in filing appeals. If an appeal is **declined**, Teams will be **deducted** 50 points from their competition set score.

26. Team shirts used to gain hardware competition points **must** display the Team Logo **and** **must** be entered in the T-Shirt competition in order to earn points.

8. Scoring

Scores are cumulative. Teams will be able to view standings and scores on a display located in proximity to playing fields, as well as digitally via google doc.

Table 1- Scoring

Points	Task
1 pt	Extra points for each blue pellet
1 pt	Extra points for each second remaining in the set after collection of *all* non-poison pellets *and* contact with the Power Pellet *and* return back home.
3 pts	Extra points for each green pellet
5 pts	Leave Home Base
5 pts	Magnetic Pellet
5 pts	Extra points for each red pellet
10 pts	Non-Magnetic Pellet
25 pts	Collect the Power Pellet
50 pts	Contact with the correctly matching stationary ghost during Power Play Phase
50 pts	Wear team T-shirts with logos
100 pts	Contact with ghosts during the Power Play Phase after successfully pushing the correctly matching stationary ghost away.
-100 pts	Collect the Poison Pellet
-50 pts	Contact with the Poison Pellet
-25 pts	Contact with a ghost before successfully completing the Power Play mission.
-10 pts	Damage to the game board elements, at the judge's discretion.

9. Questions and Answers

Further information regarding the student hardware competition may be found on the official conference website's student hardware competition page. Details regarding questions and answers are also located there:

https://attend.ieee.org/southeastcon-2021/student-program/hardware-competition/

Questions should be submitted to the appropriate channel within the conference discord server. When submitting a question mention the QA Team (@QA-Team). To Join Use:

https://discord.gg/ZTMgaxK

Alternatively, you may email questions to: HW_comp_SEC2021@ieee.org

10. Appendices

Appendix A – Game Board and Objects Specifications

Refer to Appendix B for recommendations on all paint colors.

1. Game Board Specifications:
   o The playing field will be 4' x 8' piece of plywood.
   o Playing field will be surrounded by 2" x 3" wood stud.
   o The field will be divided into a maze utilizing 2" x 3" wood stud.
   o The Game Board will be supported by a pair of sawhorses.
2. Game Board Colors
   o The game board walls (2" x 3" wood studs) are black.
   o The game board floor is white.
   o The pellets may be red, blue, green, or purple.
3. Magnetic Pellet Specifications:
   o Magnetic pellets are attractable by a magnet or electromagnet.
   o Magnetic pellets are created by cutting 2" x 3" wood studs to 1.5" in length to make a block of dimension 1.5" x 1.5" x 2.5".
   o Each side is covered with 1" x 1" sheet metal, e.g., by hot glue.
   o Color each pellet with red, blue, or green paint.
   o Magnetic pellets are slightly bigger than non-magnetic ones due to the thickness of the sheet metal.
4. Non-Magnetic Pellet Specifications
   o Non-magnetic pellets are NOT attractable by a magnet or electromagnet.
   o Non-magnetic pellets are created by cutting 2" x 3" wood stud to 1.5" in length to make a block of dimension 1.5" x 1.5" x 2.5".
   o Color each pellet with red, blue, or green paint.
5. Power Pellet Specifications
   o Power Pellets are created by cutting 2" x 3" wood stud to 3.5" in length to make a block of dimension 1.5" x 2.5" x 3.5".
   o They are **non**-magnetic pellets
   o They are purple in color with a symbol on them, either a triangle or circle.
   o Symbols will be placed on both broad faces of the Power Pellets
6. Stationary Ghost (Inky & Blinky) Specifications
   o Stationary ghosts are created by cutting 2" x 3" wood stud to 6" in length to make a block of dimension 1.5" x 2.5" x 6"
   o They are red in color with a symbol on them, either a triangle or circle.
   o Symbols will be placed on both broad faces of the stationary ghosts

Appendix B – Building Material Recommendation

- Rust-Oleum Painter's Touch 32oz Liquid Paint
  - **Note:** this is *liquid* paint, it was *previously* spray paint
  - "White" : Flat White :
  - https://www.homedepot.com/p/Rust-Oleum-Painter-s-Touch-32-oz-Ultra-Cover-Flat-White-General-Purpose-Paint-1990502/100137971

- Rust-Oleum Painter's Touch 2x 12 oz. Spray Paint:
  - "Black" : Flat Black :
  - https://www.homedepot.com/p/Rust-Oleum-Painter-s-Touch-2X-12-oz-Flat-Black-General-Purpose-Spray-Paint-334020/307244849

  - "Blue" : Satin Wildflower Blue :
  - https://www.homedepot.com/p/Rust-Oleum-Painter-s-Touch-2X-12-oz-Satin-Wildflower-Blue-General-Purpose-Spray-Paint-334080/307244959

  - "Red" : Satin Apple Red :
  - https://www.homedepot.com/p/Rust-Oleum-Painter-s-Touch-2X-12-oz-Satin-Apple-Red-General-Purpose-Spray-Paint-334094/307244870

  - "Green" : Satin Eden :
  - https://www.homedepot.com/p/Rust-Oleum-Painter-s-Touch-2X-12-oz-Satin-Eden-General-Purpose-Spray-Paint-334065/307244893

  - "Purple" : French Lilac :
  - https://www.homedepot.com/p/Rust-Oleum-Painter-s-Touch-2X-12-oz-Satin-French-Lilac-General-Purpose-Spray-Paint-334068/307244888

- Plywood
  - The 4' x 8' plywood should be smooth on one side for robot to travel.
  - Recommended thickness should be at least ¾"
  - https://www.homedepot.com/p/18mm-Sande-Plywood-3-4-in-Category-x-4-ft-x-8-ft-Actual-0-709-in-x-48-in-x-96-in-454559/203414066

- 2x3 Stud
  - Select Kiln Dried Whitewood Stud
  - Note: this is selected for least number of knots, you may utilize what is available to you and compensate with more coats of paint to ensure even color and coverage.
  - https://www.homedepot.com/p/2-in-x-3-in-x-96-in-Select-Kiln-Dried-Whitewood-Stud-845000/100038668
- Sheet Metal
  - Sheet Metal - 22 Gauge :
  - https://www.homedepot.com/p/Everbilt-12-in-x-18-in-22-Gauge-Metal-Sheet-801447/204225782
- Wood screws
  - #6 Wood screws - 1-1/4" long :
  - https://www.homedepot.com/p/Grip-Rite-6-x-1-1-4-in-Philips-Bugle-Head-Coarse-Thread-Sharp-Point-Drywall-Screws-1-lb-Pack-114CDWS1/100152392
- Stickers (Power / Poison Pellets, Stationary Ghosts)
  - 1.5" Matte White Circle Stickers
  - https://www.amazon.com/Round-Matte-Sticker-Inkjet-Printing/dp/B07Z2Q4RK2?th=1
  - Stickers will be cut to create triangle shape.
- Saw Horses
  - Construct **or** purchase 31"H Saw Horses (1 pair)
  - https://www.homedepot.com/p/Stanley-31-in-Folding-Sawhorse-2-Pack-060864R/301457796

Appendix C – Construction Recommendations

- Each surface should be sanded lightly until smooth with 300 grit sandpaper.
- All paint color should be applied with **two** coats *minimum*.
- All surfaces must be painted prior to assembly.
- Screws should be inserted from **underneath** the plywood so as to ensure the smoothest possible wall surfaces.
- The plywood surface should be painted white first, then the home base painted blue over top, and finally the start square painted black.
- The red lines indicating areas G1 – 5 are marked using Red Sharpie marker using approx. 2mm thick, single stroke lines.
- Area labels shown in board diagrams are **not** painted or marked on the constructed game board.

Create a mask or template for the half circle:

Using whatever methods are easiest to you, create a template or mask to ensure you spray paint only the semi-circle home base. In general, our process is as follows.

You will need: scrap paper or cardboard, nails or push pins, a string / wire, a pencil, a tape measure, a box cutter, painter's tape.

Make sure the white paint is completely **DRY** before proceeding. This is a reductive method; we will begin with a large piece of scrap paper / cardboard and cut out the semi-circle to create a mask.

1. Ensure that the scrap paper or cardboard is large enough to fit a cutout of a semi-circle of radius 11" + additional margins around the cutout to prevent bleed over when spray painting. Recommended additional 11" allowance.
2. Identify the center point of the bottom edge of your paper / cardboard.
3. Firmly insert a nail or push pin to this center point.
4. Tie a loop at one end of the string / wire, such that it may be placed around the nail / push pin and remain in place.
5. Measure the string / wire and cut it to a length of 11" (the radius of the semi-circle) allow for some additional length to tie another loop at the cut end.
6. At this cut end, tie another loop, around your pencil.
7. Place the free loop around the nail / push pin center point on the paper / cardboard, extend the string so that it is taught with your pencil perpendicular to the surface.
8. Begin with the pencil against the bottom edge, draw a line smoothly in an arc around the center point to again touch the bottom edge. The string should be held taught to ensure a smooth and accurate line.

9. Align the mask / template to the correct position on the board (easier prior to cutting out the semi-circle as the center point will be intact). See alignment instructions below.

Alignment of Mask / Template:

The semi-circle diameter aligns with the inner edge of the bottom 2" x 3" wall. It is therefore recommended to at least have the exterior walls in place to utilize as reference points.

1. Identify the center point of the bottom 8' wall. 48" from outside edge, 46.5" from inside corner.
2. Place your template so that the center point of the template matches the center point of the board.
3. If you haven't cut out your template this should be simple, align the nail / push pin center point of the template with the board center point.
4. Firmly attach the template to the board, using nails / push pins or painter's tape.
5. Cut out the semi-circle out of your template, using a box cutter.
6. Using the painter's tape cover any parts of the side walls that may be affected by spray painting the semi-circle.

Proceed with spray paint. Note: Spray paint **TWO** coats of color, allowing sufficient time to dry between coats.

Create a mask or template for the center square:

Using whatever methods are easiest to you, similar to the semi-circle, create a template or mask to ensure you spray paint only the start square. In general, our process is as follows.

You will need: scrap paper or cardboard, painter's tape, a tape measure, a pencil.

Make sure the blue spray paint is completely **DRY** before proceeding. This is an additive method; we will be covering areas we do **not** want painted.

1. Measure and mark the 7" square home base as it appears in the board diagram.
2. Tape and mask off any surrounding areas so that they are not erroneously painted when applying the black spray paint.
3. Make sure the tape / paper / cardboard you use to mask the area is large enough to prevent overspray.

Proceed with spray paint. Note: Spray paint **TWO** coats of color, allowing sufficient time to dry between coats.

Create and attach a camera mount:

A recommended camera mount may be constructed using 2" x 3" stud. The height should be adjusted to effectively include the entirety of the gameboard within camera view. This will depend upon the webcam model you choose to use. Below is a suggested means of construction.
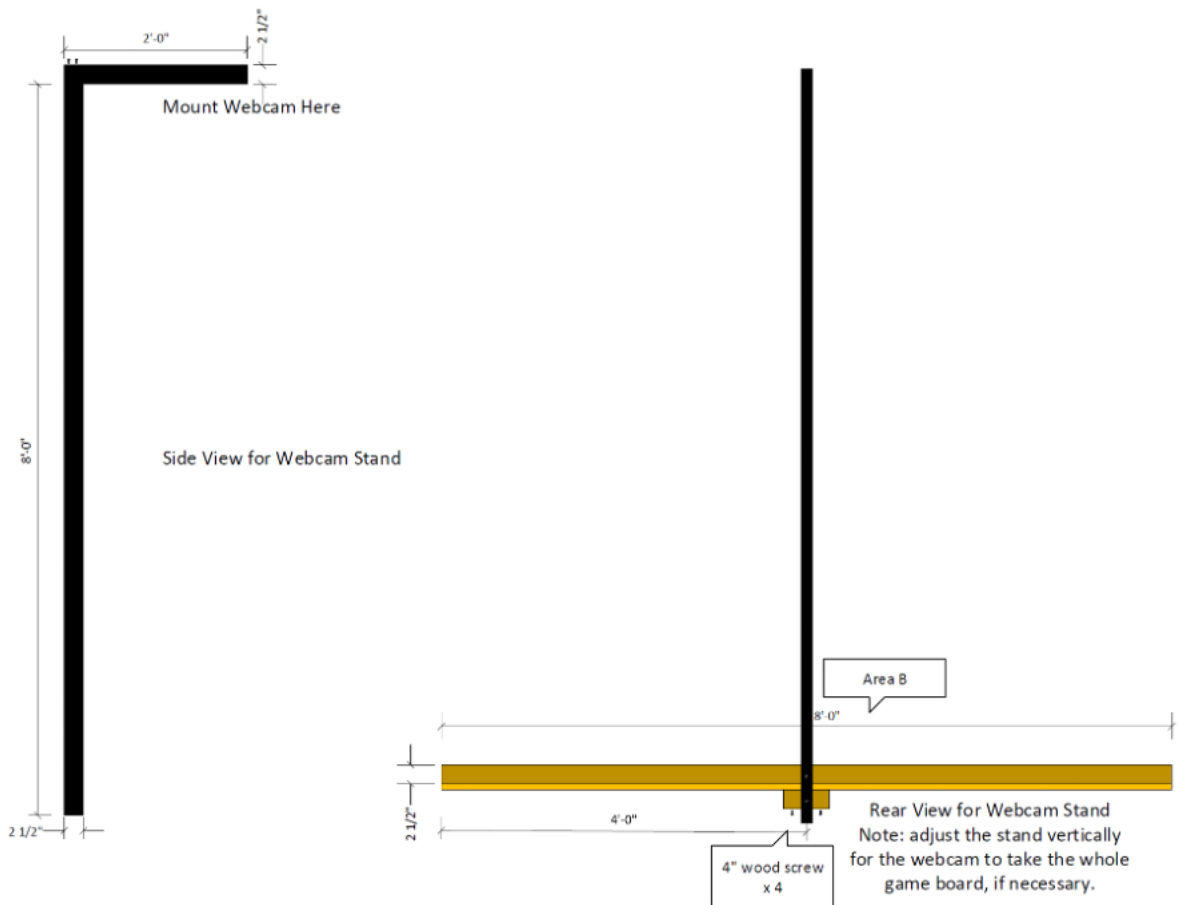

Figure 7 - Camera Mount Diagram

Appendix D – Parts List

Table 2 - Parts

Part Name	Quantity
2" x 3" Stud	7 studs
4' x 8' Plywood	1 board
#6 Wood Screws (1-1/4")	1 box (89 screws used)
Rust-Oleum White Paint	1 can
Rust-Oleum Black Spray Paint	~2 to 3 cans
Rust-Oleum Red Spray Paint	~1 can
Rust-Oleum Blue Spray Paint	~1 can
Rust-Oleum Green Spray Paint	~1 can
Rust-Oleum Purple Spray Paint	~1 can
22 Gauge Sheet Metal	1 sheet
1.5" Circle Stickers	8 stickers (1 pack)
Saw Horses	1 pair

**note: feel free to use any items you already have on hand **

Appendix E – Game Board Base Sample Photos

Figure 8 - Game Board Overlook

Figure 9 - Casters on one Long Side for Easy Transportation

Figure 10 - Side View with Casters and Sawhorses

Figure 11 - Side View

Figure 12 - Supporting 2"x3" Wood Studs on the Back Panel and Saw Horses

Figure 13 - Camera Mount Setup