

The Design Project

Contest Date: Friday 9 November 2018, 5 PM

This is it: your big design, build, and test project. You will perform this activity in groups. This is your chance to show what awesome engineers you are.

The contest is based on the movie *Fantastic Beasts: The Crimes of Grindelwald*. During the competition, you must 1) expel the Dementors from your zone, 2) separate a niffler and its gems, and 3) imprison the dark wizard Grindelwald in Azkaban. All of these tasks will be executed in the competition arena during a 40 second time period. The arena is a square having 4 sides of length 7 ft. constructed by 2X4 lumber over $\frac{1}{2}$ in plywood as shown in Figure 1. These 2X4's are oriented such that their height is 2 inches (actually 1.5) around the perimeter of the combat arena. They are stacked on top of the $\frac{1}{2}$ in plywood zone base, so the top of the zone perimeter is approximately 5.5 inches above ground. The arena has 4 home zones (Black, Blue, White and Yellow) as seen in Figure 1. Each home zone has a starting zone at the edge of the team's home zone, one of which is shown in Figure 2. At the center of the arena is Azkaban, a cylindrical unit where you must take Grindelwald. On the grounds of Azkaban, are the dens of 4 nifflers and their shiny objects. The grounds of Azkaban have a diameter of approximately 2 feet as depicted in Figure 3 and Figure 4. Specifications for the grounds are given in Figure 5 and Figure 6. Each aspect of your quest is described in the ensuing text.

Expelling the Dementors from Your Home Zone

As you probably know, Dementors are soulless creatures and among the foulest being on earth. You need to expel them from your home zone, which is defined by your assigned color in the competition arena. Figure 7 is a picture of a Dementor. You must expel the Dementor by pushing it out of your home zone. **If any part of a Dementor is located in your home zone, 13 points will be deducted from your team's score.** Please note that there are 4 Dementors in the competition arena. Each team will have a Dementor directly in front of their starting zone at the start of the competition as shown in Figure 1. Since there are 4 Dementors, there is the possibility of having multiple Dementors in your home zone at the end of the competition. Each Dementor in your home zone is worth -13 points. The specifics for the Dementor location is shown in Figure 8. Any Dementor remaining in your home zone at the end of the competition will be counted as -13 points. A Dementor is considered in your home zone if any part of this soulless creature is on, in or over your home zone. Thus, 2 teams can receive -13 points from the same Dementor if it straddles between their home zone boundaries.

Nifflers and Shiny Objects

As is well known, Nifflers love shiny objects. While they are not dangerous creatures, they can make quite the mess when looking for sparkly baubles. It happens that there are 4 Niffler nests on the grounds of Azkaban. Each Niffler nest contains a Niffler and the Niffler's shiny treasure. The Niffler nests are located at the center of the competition arena around the perimeter of Azkaban, which is a cylinder that is approximately 2 ft. in diameter as shown in Figure 3, Figure 4, and Figure 5. Azkaban rotates in the center of the arena at a rate of 5 to 12 RPM. Typical shiny objects are shown in Figure 9, and typical Nifflers are shown in Figure 10. Retrieving shiny objects will be rewarded with 4 points per shiny objects. However, for every niffler that is in your home zone at the end of the competition you will be penalized 10 points. A niffler is considered in your home zone if any part of it is on, in or over your home zone. Thus, 2 teams can receive -10 points from the same niffler if it straddles between their home zone boundaries. Note it is permissible to deposit nifflers in your competitors' some zones. To successfully collect a shiny object, you must have it completely in or above your home zone.

Imprisoning Grindelwald in Azkaban

The prison cell in Azkaban is located at the center of the track. Imprisoning Grindelwald (Figure 11) in the high security cell of Azkaban is your most important objective. Successfully imprisoning Grindelwald will result in receiving 15 points. Only one team will be able to imprison Grindelwald. As Azkaban is the highest security prison in the land, you will have to wait for the gates of Azkaban to open before imprisoning Grindelwald. At the start of your quest the gates of Azkaban will be closed and will open at some point during the competition. You must be ready to move quickly to imprison Grindelwald when the gates open. Figure 3 shows Azkaban with its gates closed and Figure 4 depicts the infamous prison with its gates open. It will take some time to open the gates. This time will be evenly distributed between 10 and 27 seconds. However, you cannot risk being far into the grounds of Azkaban for too long of a period without suffering the wrath of the Dementors. Thus, your system cannot penetrate too deeply into the grounds of Azkaban while awaiting the gates to open. You may approach the gates and touch the gates with tactile sensors, but you may not surround the gates, or in any way block your competition from the gates. While the gate is closed (up), no part of your system may be over it. Any contact with the gates for purposes beyond sensing will result in an automatic DQ. Blocking the competition from accessing the cell within the gates will also result in an automatic DQ. Your system is also not permitted to remove Grindelwald from Azkaban. Similarly, to avoid the wrath of the Dementors, you must successfully egress from Azkaban to earn your points for imprisoning Grindelwald (please read the ensuing section for more details).

Egressing from Azkaban

Azkaban is not a friendly place, and it would behoove you to not linger there too long. Therefore, you must egress from Azkaban across the void shown in Figure 1. To successfully egress from the Azkaban, your system needs to be completely outside of the void at the end of the 40 second competition time. *To receive points for imprisoning Grindelwald, your system must egress.* Furthermore, any team that successfully egresses from Azkaban will have their shiny object points doubled. A successful egress is defined as all parts of the device being

completely outside of the void. Contact with the void boundary is tantamount to being in the void. Niffler points are not affected by your system's egress status.

The Competition

Your objective is to build a machine that scores more points than other teams. You are permitted to use energy only from the electricity supplied from your controllers, 5 mousetraps, the compressed air from the charged pneumatic cylinder, and gravity. Your team will be provided with a set of actuators. Your controllers may only power the actuators supplied to you. The controller also powers the sensors supplied to you. You may also purchase additional sensors as long as your total budget remains under \$100. Please see the rules at the end of this document for details on the budget specifications.

To complicate things, three other teams will be competing at the same time. Points are awarded based on the events as described in the above text. Table 1 summarizes the point values for the various objects.

Table 1: Scoring Summary.

Task	Point Value
Retrieve Shiny Objects	4 per Shiny Object
Niffler	-10 per Niffler
Successful Egress	2X Shiny Object Score
Expelling Dementors	-13 per Dementor
Imprison Grindelwald in Azkaban	15 (must egress)

The head-to-head contest will be Friday, November 9 at 6:15 PM in the Callaway Manufacturing Research Building Atrium. From 5 PM to 6 PM, your devices will be on display in the Love Building Atrium for the design review, which is 5% of your overall ME 2110 grade. The design review score incorporates the device's ingenuity and aesthetics as judged by a group of independent observers. The design score also incorporates the quality of the team's presentation. All team members must be in attendance during the design review to discuss the features of the system. This will operate in a typical science fair type mode.

Competition Scoring

The competition score for your device will consist solely of its performance in the competition. On 9 November, every machine will be run in head-to-head competitions. The two highest scoring teams out of the four teams competing on a track will be named the winners. All machines will run in rounds 1 and 2. To compete in round 3 a machine must have been named a winner at least once during round 1 or 2. After each subsequent round, the score for each team will be tallied. The two lowest scoring teams out of the four teams competing on a track will be eliminated. Any ties will be broken by the following rating priorities:

1. Imprisoning Grindelwald in Azkaban.
2. Shiny Object Score.
3. Niffler Score.
4. Dementor Score.

5. Coin Toss

The first, second and third place finishers in the head-to-head final competition will receive most excellent prizes, and will be considered Champions of the Realm of ME 2110.

Performance Grade

Your performance grade is determined on competition day, has a maximum value of 25 points and is based on the total number of head-to-head rounds in which your machine competes (win or lose). Your performance grade will be given by the following formula:

$$\text{Performance Points} = (\text{number of rounds competed in})^2$$

While it is possible for a team to score more than 25 points using this formula, the maximum number of performance points is limited to 25 and the minimum is 4 points, unless your system does not participate in the competition.

Subsystem Competition Grade

You will have a chance to test some of your subsystems before the major competition. The subsystem scores have a maximum value of 5, 10 and 15 points and are determined by the subsystem competitions. The subsystem competitions will be held in studio on dates shown in Table 2. Each studio will hold its own subsystem events during its regularly scheduled studio time. In the subsystem events, you will have a fixed amount of time to run your machine on a track, but facing no opponent.

Table 2: Subsystem Competitions.

Subsystem Competition	Week	Date	Maximum Points (% Grade)
Expelling Dementors*	7	1-5 October	5 (1%)
Nifflers and Shiny Objects	9	15-19 October	10 (2%)
Imprisoning Grindelwald	10	22-26 October	15 (3%)

Expelling Dementors

During week 7, every individual student in the class will build a subsystem and compete individually in the Dementor expelling competition. The subsystems produced during week 7 should clear as many Dementors as possible. During week 7, you will be given 5 minutes in which you can run your machine a maximum of 3 times. The cumulative number of points your machine scores will be compared to the scores of all the machines in the entire class. For this initial event, the Dementor will only be set-up in your own home zone. Furthermore, for this initial event you will receive one point for every Dementor cleared from your home zone.

For this event, you will only be allowed to use energy from 2 mousetraps and gravity. The controller will not be used. The Dementor expelling subsystem must be activated using a

* Individual Competition.

manual motion that does not add significant energy to the system. If your machine DQ's for all 3 attempts you will receive a score of -3 (-1 for each DQ). The highest possible score for this competition is +3, and the lowest possible score is -3. Your individual point score for grading purposes in this event will be between 5 and 1, where the highest score will receive 5 points and the lowest score in all of ME 2110 will receive 1 point. Anyone receiving a score of +3 will receive 5 points, and anyone receiving a score of -3 points from 3 DQ's will automatically be given 1 point. All other individuals will receive a score that is linearly interpolated between 5 and 1 points depending on their rank in comparison to all ME 2110 studio sections. Azkaban will not be rotating during this competition.

Nifflers and Shiny Objects

During week 9, your team's subsystems should successfully complete the Niffler and shiny object task. During Niffler and shiny object event, you will be given 7 minutes in which you can run your machine a maximum of 3 times. The system must be activated using your controller and the banana plugs provided in your kit. For this event, you will be allowed to use energy from all acceptable sources as defined in the rules. The Niffler and shiny object score that your machine earns during its 3 runs will be compared to those of all the machines in all studio sections. Scoring for this event will be a bit different than the regular competition. A team will receive 4 points for every shiny object retrieved, and -10 points for every niffler in the team's home zone, as specified by the rules. However, every team will also receive an additional +10 points for every Niffler that is in an opponent's home zone. This is different from the final competition where Nifflers represent -10 points for being in your zone.

Each team will be ranked against the entire class and scored from 10 to 3 points, via linear interpolation. The highest scoring team will receive 10 points. The lowest scoring team will receive 3 points. All other teams will receive a score that is linearly interpolated between 10 and 3 points depending on their rank in comparison to all ME 2110 studio sections. If a machine fails to trigger for all of the Niffler and shiny object event attempts, it will receive 0 points. Only one subsystem should be fabricated per team for the Niffler and shiny object event that occurs during week 9. Dementors will not be present, so you will not have to be concerned with them. The grounds of Azkaban will be rotating during this competition.

Imprisoning Grindelwald in Azkaban

During week 10, your team's subsystems should successfully imprison Grindelwald in Azkaban. As in week 9, during the Nifflers and shiny object event, you will be given 7 minutes in which you can run your machine a maximum of 3 times. The system must be activated via the triggering of the track (*i.e.*, using your banana plugs). For this event, you will be allowed to use energy from all acceptable sources as defined in the rules. The cumulative number of points your machine scores will be compared to the scores of all the machines in all studio sections. For this subsystem test, the gates of Azkaban will be open for the entire competition. So you will not have to wait to have your system imprison Grindelwald. Each team will be ranked against the entire class and scored from 15 to 5 points, via linear interpolation. The highest scoring team will receive 15 points. The lowest scoring team will receive 5 points. All other teams will receive a score that is linearly interpolated between 15 and 5 points depending on their rank. If a machine fails to trigger for all of the runs, it will receive 0 points. Only one subsystem should be fabricated per team for the connecting event that occurs during week 10. For this event, the

Dementors, Nifflers and shiny objects will not be set-up in your home zone, so you will not have to be concerned with them.

Qualifying Round

The qualifying round will be held during your studios in week 11 (the week of 29 October). These will be run as full competitions with all items in play, each team competing on a one of four home zones, and will be used for the seeding of the final competition. Every machine will be guaranteed at least 3 head-to-head matches during a section's qualifying round. More head-to-head matches may be run depending on the section's size and at the instructor's discretion.

In the big competition, the better performing systems from the various studios will be pitted against those that performed less favorably in other studios. So it is to your advantage to have your system perform as best as possible in your studio. The highest scoring team in a qualifying round will receive 20 points. The lowest scoring team in any particular studio will receive 10 points. All other teams will receive a score that is linearly interpolated between 10 and 20 points depending on their rank in their respective studio sections. If a machine fails to trigger in all of the qualifying rounds, it will receive 0 points.

Once all matches used for seeding in your studio section are complete, teams from other sections can come to your studio section and participate in the qualifying rounds without affecting their own competition score. This is an excellent opportunity to practice.

Table 3: Scoring Breakdown (5 points = 1% of your final grade).

Maximum Points (% of Your Grade)	Breakdown
5 (1%)	Expelling Dementors
10 (2%)	Niffler and Shiny Objects
15 (3%)	Imprisoning Grindelwald
20 (4%)	Qualifying Round
25 (5%)	The Big Competition

Design Review Grade

The design review grade will be determined between 5 PM and 6 PM on the competition day (before your system competes). **The design review grade is 5% of your overall grade.** The team receiving the top score in the design review will receive the complete 5%, the remaining teams will have their grade scaled by their location in the class. For example, if your team receives the lowest score, it will receive 0% out of the 5%. Also, if your team is exactly at the middle (50th percentile) of the class, then you will receive 2.5% of the 5%. All design review scores will be determined by averaging of all judges' scores, and linearly interpolating between the highest and lowest design review scores. A copy of the judge's scoring sheet will be available on the web site to calibrate you as to what they will be considering when they are judging you.

Grading

For grading purposes, your system's overall score counts towards 15% of your grade for the course. Thus, 5 points = 1% of your grade. The breakdown of the total amount of the 50 points is shown in Table 3. Note the design review grade does not affect the performance grade.

Rules

1. The competition zone is a square with sides of 7 ft. as shown in Figure 1. The arena will be bounded by 2X4's such that they form a 1.5 in. wall around the arena. There may be some slight differences between the floor surfaces of the various tracks (*e.g.*, the one track may be a bit rougher than another). Your device should be engineered to be robust to these differences.
2. For the head-to-head competition, your device will be assigned an 8 minute time block. All four devices will be automatically activated at the 3 minute mark, and must be removed from the track by the 8 minute mark. Your machine must be ready to run at the 2:45 minute mark. This provides a 15 second buffer between set-up and run. Thus, you will have 2:45 minutes to set-up your device and 40 seconds to have it complete its task. By the end of the 8 minute period you must have removed your device (and any bits and pieces) and cleaned-up the competition track. Your system will be disqualified for taking longer than your allotted time.
3. You will have a minimum of 3 minutes to prepare for the next round.
4. It is your responsibility to be on time with a working machine. If you are not present during your assigned time, you forfeit the round.
5. The source of power in your device is limited to the five mousetraps provided to you, power provided to your system from a controller box, a charged pneumatic tank, and gravity. Air from the pneumatic tank may only be used to power pneumatic actuators, and may not be vented directly to the environment.
6. The only powered actuators that you are permitted are the ones that are supplied to you by the ME 2110 staff. You may purchase additional sensors as long as your budget remains under \$100.
7. The device must fit within a 12 in. x 24 in. x 18 in. (length x width x height) box (see Figure 12). Your device will be measured with a go-no-go gage immediately before each attempt. All parts of the device will be measured. The 18-inch dimension is the maximum starting height of your system. All measurements are to be made on the 30 in. X 30 in. starting zone.
8. The device must be launched from within the 30 in. X 30 in. starting zone as shown in Figure 2. The outside of the lumber perimeter defines one of the sides of the starting zone. You may place your device in any configuration or orientation within the starting zone; however, the go-no-go box (rule #7) must be able to fit over the device immediately prior to its start. You may reposition your device after it has been checked for size, but may not change any aspect of the machine. The tops of the 30 in. X 30 in. boundaries of the home zones are not considered part of the zones.
9. There will be an area around the competition arena, marked off by tape on the floor that is off limits during the competition.

10. The device must be safe. It must not damage, stain, or permanently change the competition track or its surroundings and competition items. Neither adhesives nor Velcro-type materials (*e.g.*, hook and loop binding) may be used to interact with the track or the competition items. The device should not scratch the floor. It must not injure bystanders or you. The faculty will disqualify any device they deem unsafe, resulting in zero points for the competition.
11. Once it has been activated, you may not touch, or even appear to touch, the device until the staff member in charge of the competition arena indicates it is time to clear out the arena. If a team approaches the track before they are cleared to do so (*e.g.*, rushes the track), their system will be disqualified from that round.
12. No device may throw any projectile such as a net or rope over the Teleportation Chair. Any such action will result in the disqualification of your system.
13. No group may spend more than a total of \$100 on the device. You will be required to document the cost of your materials by submitting your receipts as well as a bill of materials (BoM). Material may be prorated for costs. You may use free material; however, your BoM must show the cost of that material as prorated from some verifiable source. The cost of an object is defined to be that which Joe P. Citizen must incur in obtaining the object. For donated or scrounged material, an equivalent price must be specified.
14. The cost of the mousetraps, sensor and supplied actuators is NOT included in the \$100. The \$100 is out of pocket expense; you will not be reimbursed for the expense by the School.
15. The costs of any aesthetic materials (*e.g.*, paint) and fasteners (*e.g.*, staples, tape and glue) are not included in the \$100.
16. The device shall not be permanently bonded in any manner to the competition track or its surroundings in any way.
17. The device must be activated by using the start plug on the right side of your respective staring zone. The start plug circuits will be closed during the 40 second competition and open otherwise.
18. The device must shut down/stop moving at the end of the 40 second when the start plug circuits are opened. Failure to do so will result in a disqualification.
19. The device must operate autonomously. No remote control is allowed.
20. The device may touch or otherwise utilize any part of the competition track or its surroundings. It may not utilize or interact with any living person or living object during the competition.
21. False starts will result in a disqualification of the offending device.
22. Disqualification is defined as forfeiting the particular round in which the disqualification offense occurs.
23. While machines may go outside of the combat zone, there are no guarantees as to what will be located outside of the track (*e.g.*, a wall, pillar, trigger box or person may be located outside of the track area).
24. The 2X4 border around the track is not considered part of your home zone.

25. The faculty will assign the groups. The groups will remain constant for the duration of the project. The faculty has the right to remove or otherwise penalize disruptive members of any group, including reducing the project grade for individual students if deemed appropriate by the faculty.
26. The faculty's rulings are binding and final.
27. Wanton destruction of opposing devices or competition arena is strictly prohibited.
28. All ME 2110 are to be conducted in a professional manner and, therefore, any inappropriate language or behavior will result in disqualification. The presence of parents, grandparents and young children at the event further strengthens the case for a respectful and professional code of conduct. In general, if you have to ask if an action is rude or inappropriate, or if certain language is unacceptable, you should avoid it.
29. No actuators (*e.g.*, valves, solenoids) can be activated prior to the start of a round. Actuators must be in their resting state at the start of a round.
30. You may not use elastic energy (*e.g.*, additional springs beyond the mousetraps, rubber bands, flexed materials) to provide significant power for point-scoring actions or mechanisms. Additionally, no magnets are allowed.
31. If your device fails to trigger or has made no perceptible motion after the round has started, this will result in disqualification.

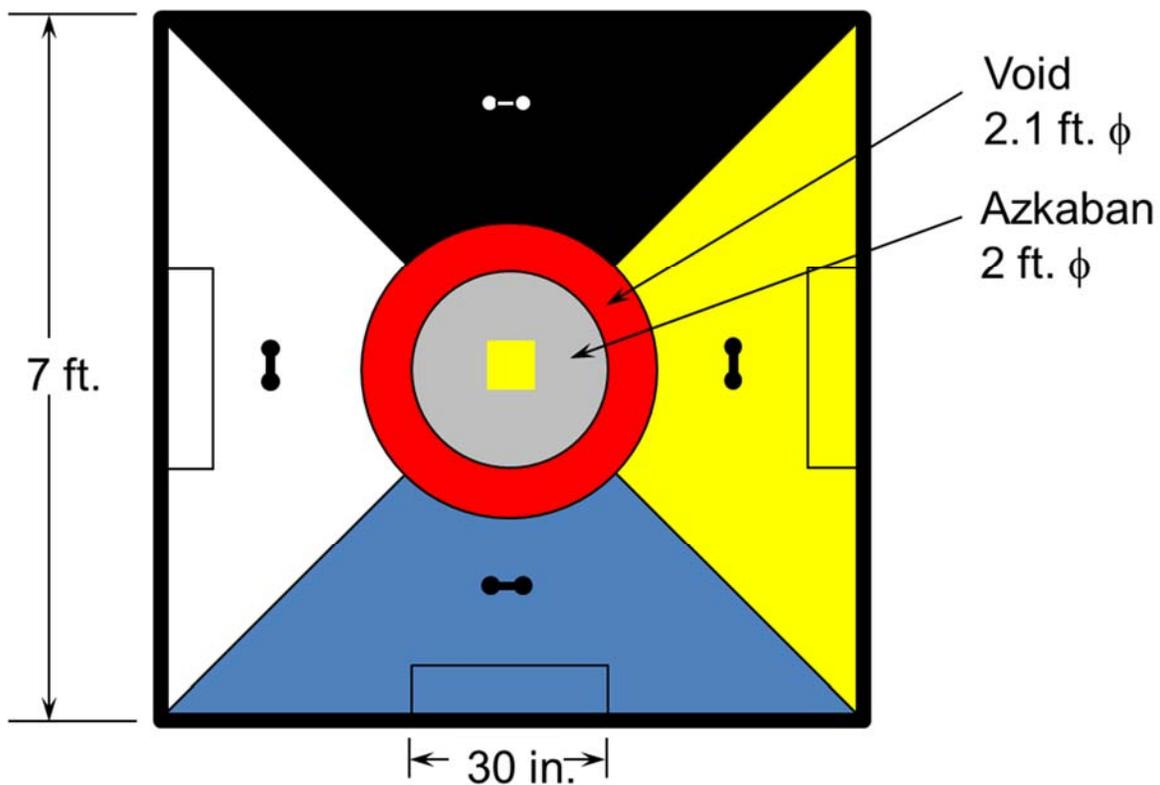


Figure 1: The Competition Arena.

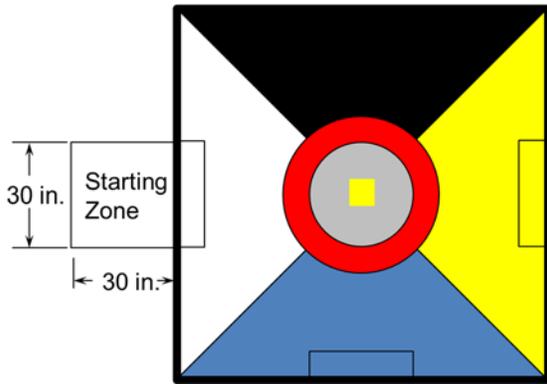


Figure 2: Typical Starting Zone.



Figure 3: Azkaban (Gates Closed).



Figure 4: Azkaban (Gates Open.)

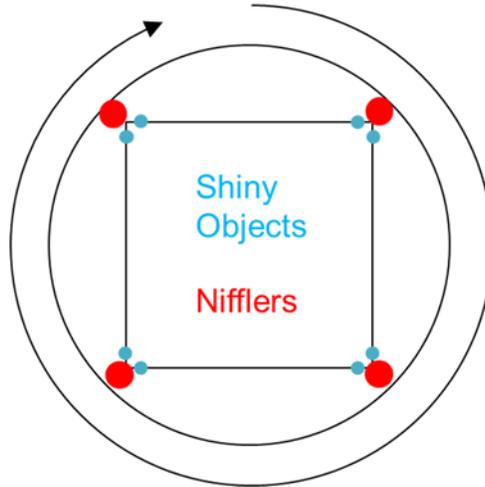


Figure 5: Azkaban Top View.

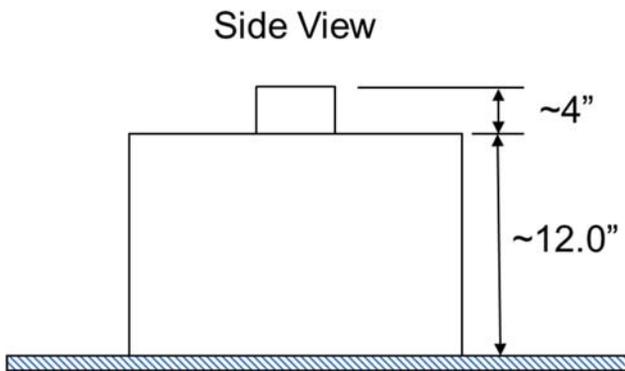


Figure 6: Azkaban Side View.



Figure 7: A Dementor.

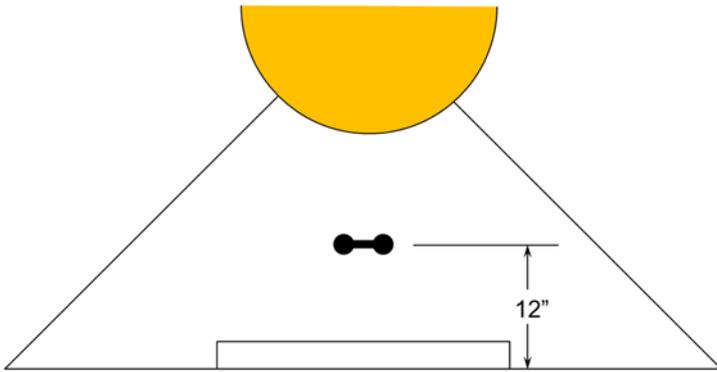


Figure 8: Location of Dementor.



Figure 9: Shiny Objects.

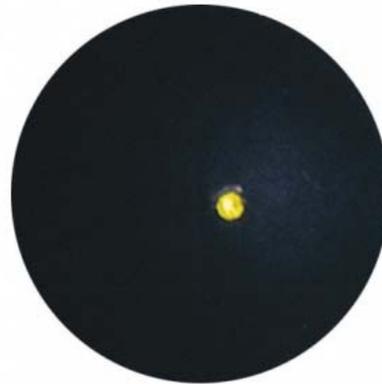


Figure 10: A Niffler.



Figure 11: Grindelwald.

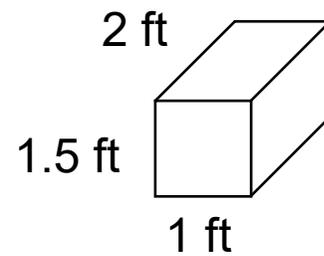


Figure 12: Starting Size.