GEORGIA INSTITUTE OF TECHNOLOGY
George W. Woodruff School of Mechanical Engineering
ME 2110 - Creative Decisions and Design
Fall 2015

The Design Project

Contest Date: Friday 13 November 2015, 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 *Star Wars series*. During the competition, you must defeat the Empire by: 1) forcing Darth Uga in his Tie Fighter to egress from your base sector, 2) launching the Millennium Golf Ball and safely returning the fleet to your base sector, 3) dropping proton torpedoes in the Death Star's equatorial trench, and 4) finally, your device must egress from the vicinity of the Death Star to avoid structural and radiation damage when the Death Star is destroyed. All of these tasks will be executed during a 40 second time period. The combat zone is a square having 4 sides of length 7 ft. constructed by 2X4 lumber over ½ 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 zone. They are stacked on top of the ½ in plywood zone base, so the top of the zone perimeter is approximately 2 inches above ground. The combat zone has 4 base sectors as seen in Figure 1, including 4 impenetrable galactic barriers that span 2 based sectors. A picture of a typical galactic barrier is shown in Figure 2. At the center of the combat zone is the Death Star, a hemispherical entity having a diameter of approximately 2 feet as depicted in Figure 3. The Death Star specifications are given in Figure 4. Each aspect of the battle plan is described in the following text.

<u>Defeating Darth Uga</u>

Darth Uga will be out to try and stop your attack on the Death Star in his Tie Fighter. Figure 7 shows a classical Tie Fighter, one of the Evil Empire's most advanced short range attack craft. You must defeat Darth Uga by pushing his Tie Fighter out of your base sector. **If any part of the Tie Fighter is located in your base sector, 13 points will be deducted from your team's score.** Please note that there are 4 Tie fighters in the combat zone. Thus, there is the

possibility of having multiple Tie Fighters in your base sector at the end of the competition. Each Tie Fighter in your base sector is worth -13 points. The Tie Fighters will be located on the border of your base sector, as shown in Figure 8. Any Tie Fighter remaining in your base sector at the end of the competition will be counted as -13 points. A Tie Fighter is considered in your base sector if any part of it is on, in or over your base sector. Thus 2 teams can receive -13 points from the same Tie Fighter if it straddles between their base sector boundaries.

Launching the Millennium Golf Ball

The Millennium Golf Ball is critical to the defeat of the Death Star, and must be successfully launched from your system. A successful launch is defined by the top of the Millennium Golf Ball being raised at least 3 inches above the 18 inch starting zone. **Raising the Millennium Golf Ball at least 3 inches will result in your team earning 10 points. The team that raises the Millennium Golf Ball the highest will receive an additional 30 points.** Figure 9 is an image of the Millennium Golf Ball. The altitude of the Millennium Golf Ball is defined by the highest point on the ship. This must be clearly visible for a measurement to be made.

Returning the Fleet

After the battle, the fleet must return to your base sector. Figure 8 shows a number of the ships in your fleet, and shows the starting position of the fleet. Please note that there are a number of ships per sector and they are all fair game for each team. **Each ship that you can return to your base sector is worth 7 points**. A ship must be completely in or over your base sector to receive its 7 points.

Torpedoing the Death Star

The Death Star is a hemisphere that is approximately 2 ft. in diameter as shown in Figure 3 and Figure 4. It rotates in the center of the combat zone at a rate of 5 to 12 RPM. To destroy the Death Star, you must drop proton torpedoes in its equatorial trench. Typical MK 50 proton torpedoes are shown in Figure 6. Your attack craft will be equipped with 6 fully armed MK 50 proton torpedoes that will be armed and supplied to you just before your systems take the track. As shown in Figure 4 and Figure 5, the Death Star Target Map, the equatorial trench has 4 quadrants. Each quadrant in the trench must be successfully attacked. A successful attack is defined as having one of your torpedoes in the trench quadrant. Only one torpedo needs to be in

the quadrant, and no extra points can be earned for having multiple torpedoes in any particular trench quadrant. The trench is approximately 9.5 inches above the arena and is approximately 3 inches high. It has a slight lip (approximately 0.5 inches) on it to prevent the torpedoes from rolling out. Your torpedo score is dependent on the number of quadrants successfully attacked. If no torpedoes are successfully dropped on the Death Star, a score of zero will be given to your team's torpedo run. Torpedo scoring information is provided in Table 1.

Table 1: Torpedo Scoring Information.

Number of Quadrants Successfully Torpedoed	**Point Value**
0	0
1	1
2	3
3	9
4	27

Finally, you must egress from the blast zone shown in Figure 1 and Figure 5 so that your unit is not damaged when the Death Star explodes. To successfully egress from the blast zone, your system needs to be completely outside of the blast zone at the end of the 40 second competition time. Any team who successfully egresses from the blast zone will have their torpedo points doubled. A successful egress is defined as all parts of the device, with the exception of the torpedoes, being completely outside of the blast zone. Contact with the blast zone boundary is tantamount to being in the blast zone.

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 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 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 2 summarizes the point values for the various objects.

Table 2: Scoring Summary.

Task	Point Value
Torpedoing 1 Quadrant	1
Torpedoing 2 Quadrants	3
Torpedoing 3 Quadrants	9
Torpedoing 4 Quadrants	27
Successful Egress	2X Torpedo Score
Recalling the Fleet	7 per ship
Tie Fighter in Base Sector	-13 per Tie Fighter
Launching the Millennium Golf Ball	10
Maximum Altitude for Millennium Golf Ball	30

The head-to-head contest will be Friday, 13 November at 6:15 PM in the MARC Building Atrium. From 5 PM to 6 PM, your devices will be on display in the MARC Auditorium 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 member will need to 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 13 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. Maximum altitude for Millennium Golf Ball
2. Most Zones Successfully Attacked.

3. Successful Egress from Blast Zone.
4. Most Ships from Fleet in Base Sector.
5. Fewest Tie Fighters in Base Sector.
6. Coin Toss

The first, second and third place finishers in the head-to-head competition will receive prizes.

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 points and 10 points and are determined by the subsystem competitions. The subsystem competitions will be held in studio on dates shown in Table 3. 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. Remember that due to fall break, there is no competition during week 9, but attendance during studio is still mandatory.

Table 3: Subsystem Competitions.

Subsystem Competition	Week	Date	Maximum Points (% Grade)
Darth Uga Engagement*	8	5-9 October 2015	5 (1%)
Millennium Golf Ball Launch	10	19-23 October 2015	10 (2%)
Torpedo Run	11	26-30 October 2015	15 (3%)

* Individual Competition.

Darth Uga Engagement

During week 8, every individual student in the class will build a subsystem and compete individually in the Darth Uga/Tie Fighter Clearing competition. The subsystems produced during week 8 should clear as many Tie Fighters (remember there are 2 of them in your base sector) as possible. During week 8, 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 Tie Fighters will only be set-up in your own base sector. Furthermore, for this initial event you will receive one point for every Tie Fighter cleared from your base sector.

For this event, you will only be allowed to use energy from 2 mousetraps and gravity. The controller will not be used. The Tie Fighter clearing subsystem must be activated using a manual motion that does not add significant energy to the system. Other base sectors on the track will be left empty. Each individual will be ranked against the entire class and scored from 1 to 5 points, via linear interpolation. The Death Star will not be rotating during this competition.

Millennium Golf Ball Launch

During week 10, your team's subsystems should successfully launch the Millennium Golf Ball. As in week 8, during the Tie Fighter clearing event, you will be given 5 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 cumulative launch altitude your machine delivers will be compared to those of all the machines in all studio sections. Each team will be ranked against the entire class and scored from 3 to 10 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 15 and 3 points depending on their rank. If any machine fails to trigger in any of the Millennium Golf Ball launches, it will receive 0 points. Only one subsystem should be fabricated per team for the Millennium Golf Ball launch event that occurs during week 10. For this event, neither the fleet, nor any Tie Fighters will be set-up in your base sectors, so you will not have to be concerned with them. The Death Star will not be rotating during this competition.

Torpedo Run

During week 11, your team's subsystems should successfully complete the torpedo run. As in week 8, during the Tie Fighter clearing event, you will be given 5 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. Each team will be ranked against the entire class and scored from 5 to 15 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 any machine fails to trigger in any of the torpedo runs, it will receive 0 points. Only one subsystem should be fabricated per team for the torpedo run event that occurs during week 11. For this event, neither the fleet nor any Tie Fighters will be set-up in your base sectors, so you will not have to be concerned with them.

Qualifying Round

The qualifying round will be held during your studios in week 12 (the week of 2 November). These will be run as full competitions with all items in play, each team competing on a base sector, 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 sections size and at the instructor's discretion.

In the big competition, the best performing systems from the various studios will be pitted against those that performed the worst 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 any machine fails to trigger in any 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 4: Scoring Breakdown (5 points = 1% of your final grade).

Maximum Points (% of Your Grade)	Breakdown
5 (1%)	Darth Uga Engagement
10 (2%)	Millennium Golf Ball Launch
15 (3%)	Torpedo Run
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 (50^{th} 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 10% 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 4. Note the design review grade does not affect the performance grade.

Rules

1. The combat 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.
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" x 24" x 18" (length x width x height) box (see Figure 10). 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 in your team's base sector.
8. The device must be launched from within the 2 ft. x 1 ft. starting zone as shown in Figure 1. 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 2 ft. x 4 ft. boundaries of the base sector are not considered part of the sectors
9. There will be a 3 ft area around the combat zone, 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 it surroundings. In particular, it 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 Death Star. 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 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.
25. The faculty's rulings are binding and final.
26. Wanton destruction of opposing devices or competition arena is strictly prohibited.

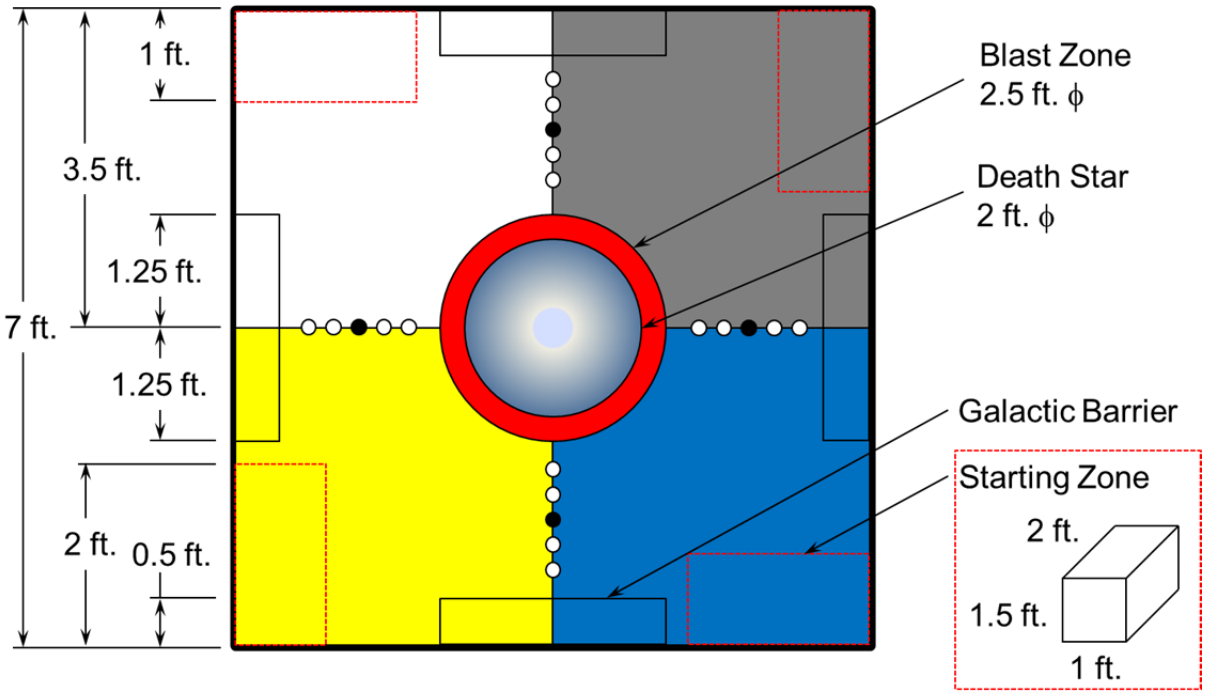

Figure 1: The Combat Zone.

Figure 2: A Galactic Barrier.

Figure 3: The Death Star.

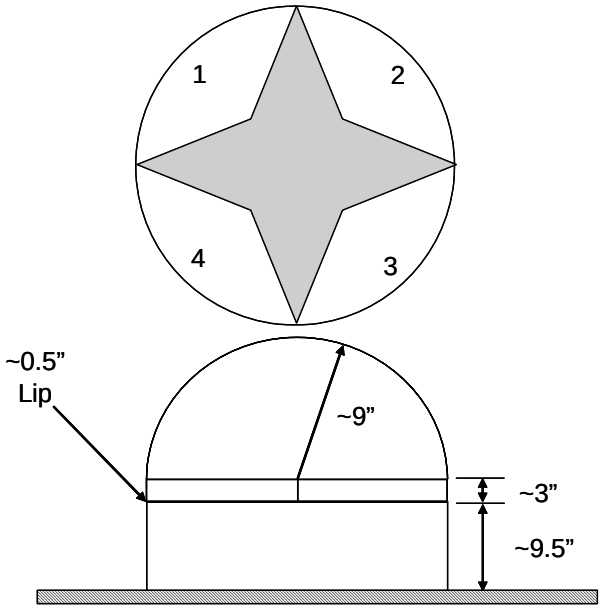

Figure 4: Death Star Trench Layout.

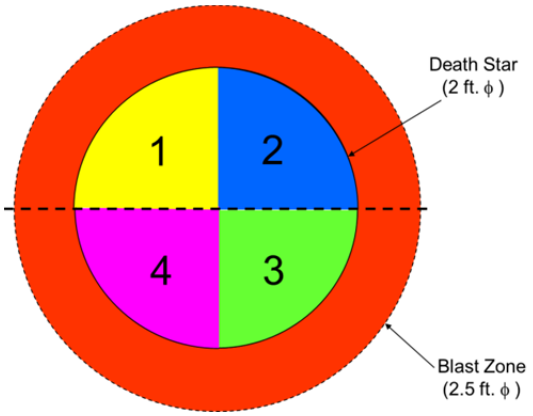

Figure 5: Death Star Target Map.

Figure 6: Standard MK 50 Proton Torpedoes.

Figure 7: Classic Tie Fighter.

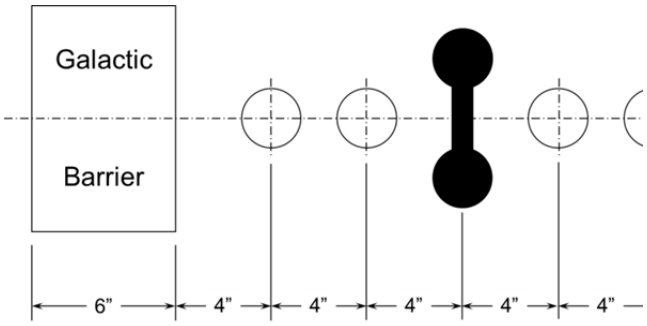

Figure 8: Tie Fighter (in Black) and the Fleet.

Figure 9: The Millennium Golf Ball.

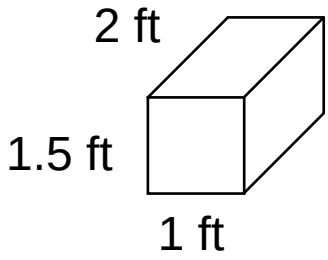

Figure 10: Starting Size.