

# The Kentucky Derby

MCHE 201: Introduction to Engineering Design  
Spring 2019 – Final Project

## 1 Introduction

In the time since its inception in 1875, the Kentucky Derby has grown into a grand American tradition. Each year over one hundred thousand spectators flock to Churchill Downs to be a part of the Kentucky Derby festivities and to watch the 1 1/4 mile long horse race. Millions more watch on television. The Kentucky Derby is home to a host of traditions. Spectators are typically well dressed, and female attendees often wear large, fancy hats. Another tradition is the awarding of a blanket roses to the winner. Given its prestige, the road for competitors to the Derby is a hard one, for the horses, jockeys, and trainers. Luckily, *MCHE201* students can help.

*MCHE 201* students will design and build devices that have thirty seconds to *Complete Training Runs*, *Collect Carrots*, *Collect Lucky Horseshoes*, *Finish Strong Down the Home Stretch*, *Send Jockeys to Churchill Downs*, and *Collect the Winner's Roses*. The capabilities of these devices will be demonstrated on the representation of the Kentucky Derby shown in Figure 1. The Derby consists of four team-zone-and-starting-zone pairs. Each triangular slice of the square, defined by the crossing diagonals minus the area of the Churchill Downs (the square center section), is considered a team zone. The Start Zone for each team is *not* considered part of the team zone. For each round of competition, the competing teams will each be assigned one zone. The devices should:

1. **Complete Training Runs:** In each team zone, two Training Cones (small cones) are located in front of the Stable. To train for the Kentucky Derby, the Training Cone must be *completely* removed from the team zone. For each Training Cone that remains in the team zone, the team will be **penalized 15 points**.
2. **Collect Carrots:** There are five carrots (small toy carrots) in each team zone. For each carrot that is collected and placed *completely* in the Stable within the team's zone, the team will **earn 5 points**.
3. **Collect Lucky Horseshoes:** Lucky Horseshoes (plastic horseshoes) are located at the edges between the team zone and each of its neighbors. For each horseshoe collected *completely* into the team's zone, the team will **earn 15 points**.
4. **Finish Strong Down the Home Stretch:** In order to win the race, you have to finish strong down the home stretch. To do so, the team's device must be *completely* outside the team's zone at the end of the round of competition. Doing so will **earn 15 points**.
5. **Send Jockeys to Churchill Downs:** Prior to the each competition round, each team will be given three Jockeys (LEGO minifigures). For Jockey that makes it to Churchill Downs, the team will **earn 5 points**. For each who makes it to the rotating Winner's Circle, the team will **earn 15 points**. In order to earn the points for the Winner's Circle, the Jockey must be *completely* contained in the Winner's Circle, including in the vertical dimension. If a Jockey is not completely contained in the Winner's Circle, but is still within the Churchill Downs, Churchill Downs points will be awarded as appropriate.

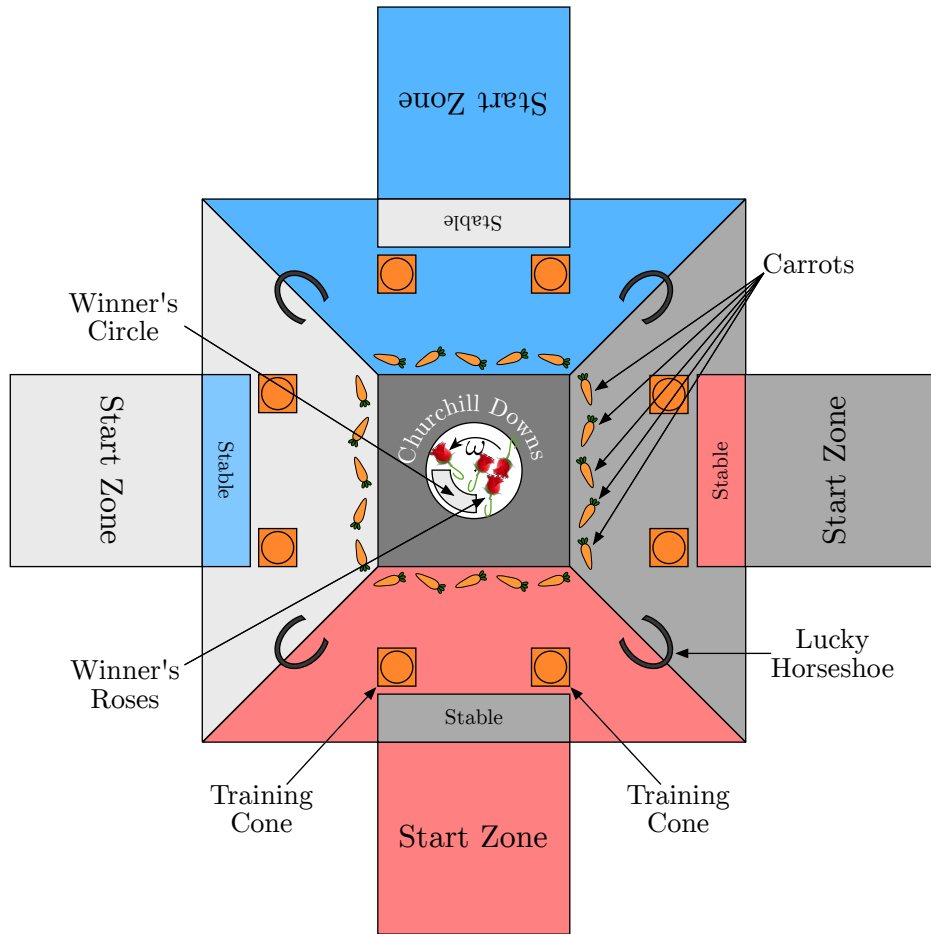


Figure 1: The Kentucky Derby

6. **Collect the Winner’s Roses:** There are four roses (cloth roses) waiting for the winner in infield of Churchill Downs. For each Winner’s Rose *completely* collected into the team’s zone, the team will **earn 50 points**.

## 2 The Competitions

Teams will need to demonstrate the capabilities of their machine on four different occasions.

### 2.1 Individual Contest

Every student will build a device and compete in an Individual Contest, scheduled for March 19. Each machine should complete a simplified version of the *Complete Training Runs* task. In this contest, only the Training Cones will be set up. For this contest only, +10 points will be awarded for each training run completed by *completely* removing the Training Cone from the team zone.

This competition does not utilize any of the electronics available; it is a purely mechanical design. The machine must be manually triggered and cannot receive any significant energy from its student operator. That also means that it must start from a stable equilibrium condition.<sup>1</sup> Each device will be run at most 2 times in 3 minutes, and the score will be the sum of the two attempts. **1 of the possible 15 total Robot Performance grade points will come from this competition.**

## 2.2 Preliminary Competition

On April 2, the machine must demonstrate that it is able to *Complete Training Runs*, *Collect Carrots*, and *Collect the Winner's Roses*. The machine must be electronically triggered and operate autonomously. During this contest, the machines will be alone. Each team will have 5 minutes to run their machine at most 3 times. The score will be the sum of the three attempts. **3 of the possible 15 total Robot Performance grade points will come from this competition.**

## 2.3 Qualifying Round

On April 11, a qualifying round will be held with all competition rules and scoring in effect. The results of this competition will be used to seed the final competition bracket, and the competition will continue until a clear ranking is evident or class time runs out. **3 of the possible 15 total Robot Performance grade points will come from this competition.**

## 2.4 Final Competition

On April 25, the final competition will be held. There will be two events in this contest.

**Design Review:** A panel of judges will perform a design review of the machines. Each team will need to clearly and concisely describe their machine to the judges. The judges will evaluate the teams on aesthetics, ingenuity, and presentation. **5 of the 55 possible total Final Project grade points will come from this design review.**

**Robotics Contest:** The robots will compete in head-to-head competition. **8 of the possible 15 total Robot Performance grade points will come from this competition.**

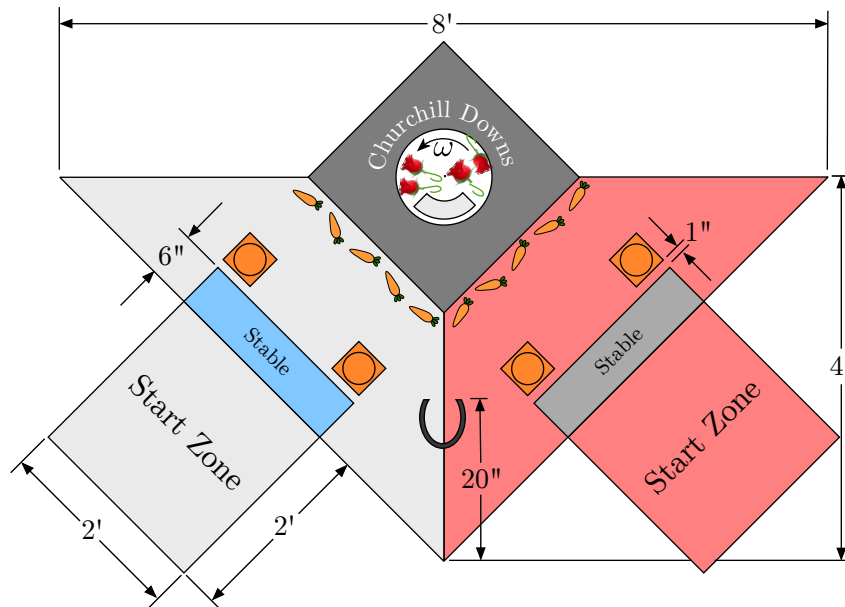
# 3 Details

## 3.1 The Kentucky Derby

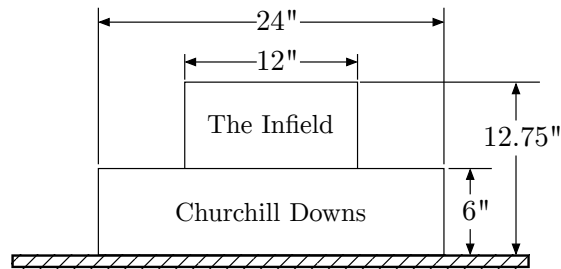
The approximate dimensions of the Kentucky Derby are shown in Figure 2(a). The approximate dimensions of the center section, Churchill Downs, are further detailed in Figure 2(b). Note that

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<sup>1</sup>For example, the student builder/operator can not be holding the device, then release it to start a trial, as they'd be imparting significant energy to hold it away from an equilibrium condition.



(a) Approximate Dimensions of the Kentucky Derby



(b) Approximate Dimensions of the Churchill Downs

**Figure 2: Approximate Dimensions**

these dimensions are approximate and that robots should be robust to variation and uncertainties in them.

### 3.2 Construction Materials

Each team is permitted to use one pyboard microcontroller and the components contained in three of the student-purchased kits. The components of the kit that each team has been given for the contest can also be used.

Each team is also allowed to purchase construction materials and additional sensors, but the total cost may not exceed \$100. *No* additional actuators can be used. A bill of materials should be included in final report to document these costs. For devices nearing the \$100 limit or suspected

of exceeding it, receipts or other documentation of costs may be requested.

### 3.3 Tie Breaker Procedure

In the event of a tied contest, the following tiebreakers will be used in order until a winner can be determined:

1. Points from *Collect the Winner’s Roses*
2. Points from *Send Jockeys to Churchill Downs*
3. Points from *Collect Lucky Horseshoes*
4. Points from *Finish Strong Down the Home Stretch*
5. Points from *Collect Carrots*
6. Points from *Complete Training Runs*
7. Coin toss

### 3.4 Grading Summary

The performance of the robots will determine 15 of the 55 points available for the final project. Another 5 grade points will be determined by the Design Review. The division of these points is summarized in Table 1. Additional grade points from this project are determined by project reports and presentations. The division of those grade points is explained in the class syllabus.

#### 3.4.1 Individual Contest

The student(s) whose device(s) received the maximum total score during the Individual Contest will earn 1 grade point, and the student(s) whose device(s) received the minimum score will earn 0.1 point. The grade for scores between the minimum and maximum will be based on a linear interpolation between these values. Failure to compete in this contest will result in a grade of 0 for this part of the robot performance grade.

#### 3.4.2 Preliminary Contest

For the Preliminary Contest, the student(s) whose device(s) received the maximum total score will receive 3 grade points, and the student(s) whose device(s) received the minimum score will receive

**Table 1: Grading Summary**

Maximum Available	Event
1	Individual Contest
3	Preliminary Contest
3	Qualifying Round
8	Final Contest
5	Design Review

1 point. The grade points for scores between the minimum and maximum will be based on a linear interpolation between these values. Failure to compete in this contest will result in a grade of 0.

### 3.4.3 Qualifying Contest

The Qualifying Contest is a full test; all contest rules apply. The score will reflect the team's ranking within the class. The highest ranked team will receive 3 points, and the lowest ranked will receive 1 point. The grade points for rankings between the highest and lowest will be based on a linear interpolation between these values. Failure to compete in this contest will result in 0 grade points. This round of competition also determines the initial seeding for the final contest.

### 3.4.4 Final Contest

The grade points for the Final Contest are based on the the final contest ranking of the robot. The winning team earns 8 grade points. Teams with zero wins earn 4 grade points. Other teams' grade points are scaled linearly between these values according to their final contest ranking. Failure to compete in this contest earns 0 grade points.

### 3.4.5 Design Review

The judges' scores will be summed and divided by the number of judges that evaluate each robot. These resulting, average scores will be ranked across the class. The maximum score will earn 5 grade points, and the minimum score earns 2 grade points. All other scores will be scaled linearly between these two.

## 3.5 Contest Rule Details

1. If a team is disqualified for a rules violation, then they lose the current match in which they are competing. If the team can eliminate the violating offense, then they are eligible for future matches.
2. For the each round of contest, the devices will be assigned to a 7-minute time block. All competing devices will be automatically activated at the 4-minute mark, and must be removed from the track by the 7-minute mark. There is a 4-minute block of time dedicated to device setup. The devices will compete for 30 seconds. The next 2.5 minutes will be used for scoring and cleaning up. By the end of the 7-minute period, teams must remove their device (and any bits and pieces), return any competition pieces, and clean up their zone of the competition track. Disqualification can be imposed for taking longer than the allotted time.
3. Points are awarded according to the steady-state location of items at the end of the 30-second run time.

4. Devices that are not ready for competition 15 seconds prior to the start of a round will be disqualified. *Note:* This means that of the 4-minute block of time dedicated to device setup, only 3 minutes and 45 seconds is actually available.
5. All zones are defined as the immediate area on the competition track as well as the volume above the zone, unless otherwise stated in the contest rules.
6. The device must be launched from within the  $2 \times 2$ -foot starting zone. The devices may be placed in any configuration or orientation within the starting zone; however, it must be completely contained in the zone.
7. The  $2 \times 2$ -foot starting zone is not considered to be part of the team's zone.
8. The robot must fit within a 1-foot  $\times$  2-foot footprint. It also must be less than 18 inches tall. It may be oriented any way that fits within the  $2 \times 2$ -foot starting zone.
9. Each device will be measured with a go/no-go box during the 4-minute setup period. When the box is removed, the machine may not "bloom" out and occupy a larger volume. Doing so will require a re-boxing of the machine. If the device has not been cleared to compete by 15 seconds before the start time of the round of competition, it will be disqualified for that round.
10. Once the device has been boxed to check its dimensions, teams can only reposition the device. Teams cannot set/reset triggers, adjust components, turn on the controller, etc. Doing so will result in the device having to be re-boxed. The device may be translated and/or rotated post boxing, but it must move as a rigid body. If the device changes size or "blooms" during final positioning, it will need to be re-boxed.
11. Once teams have exited the setup area following boxing, teams may not interact with the device or enter the competition area. Doing so during the allowed setup time will result in the device needing to be re-boxed. Doing so outside of the setup time and before an official has indicated it is time to clear out the machine will result in a disqualification.
12. It is each team's responsibility to be on time with a working machine. If a team is not present during their assigned time, they are disqualified for that match.
13. A three-foot perimeter around the competition area, marked by tape, will be off limits during the competition. Entering the zone during a competition round will result in disqualification.
14. The device must be safe. It must not injure bystanders or team members. It must not damage, stain, or permanently change the competition area, components, or its surroundings. It must not scratch the floor. The faculty will disqualify any device they deem unsafe.
15. Each team may not spend more than a total of \$100 on the device. Teams should be prepared document the cost of the materials by submitting their receipts. A table of materials and costs should be included in the final report. Material may be prorated for costs. The cost of an object is defined to be that which Joe P. Citizen must incur in obtaining the object. For donated, recycled, or scrounged material, an equivalent price must be specified.
16. The cost of the student-purchased pyboard kits is *not* included in the \$100.

17. The \$100 is out of pocket expense; it will not be reimbursed.
18. The costs of any aesthetic materials (*e.g.*, paint) and fasteners (*e.g.* staples, tape, and glue) are not included in the \$100 budget.
19. Any and all supplies provided (extra electronics, motors, etc.) must be returned in good working order.
20. The device shall not be bonded in any manner to the competition track or its surroundings.
21. The device must be activated by using the start plugs near the starting zone. The start plug circuits will be closed during the thirty-second competition and open otherwise. The control code must sense the closed circuit and activate its actions.
22. Power to the robots will be available from outlets near the starting zones, which will remain powered for the duration of the contest. In other words, they do not power on/off with the start switch; they are always on. If the robot travels far out into the competition area, teams must supply their own extension cord.
23. The robots cannot have active (powered applied) components prior to triggering. (*i.e.* solenoids and motors must be powered off).
24. The device must shut down (*i.e.*, no electric motors, etc. operating) at the end of the thirty-second competition. Failure to do so will result in disqualification.
25. The only power sources that the robots can use are gravity and the energy from the allowed kit components.
26. The device must operate autonomously. No remote control is allowed.
27. The device may touch or otherwise utilize any part of the arena or its surroundings. It may not utilize or interact with any living person or living object, such as trained alligators, during the competition.
28. False starts that disrupt the playing field such that it cannot be reset in time for the scheduled start of the competition round will result in a disqualification of the offending device.
29. While machines may go outside of the playing field, there are no guarantees as to what will be located outside of the track, *e.g.*, a wall or motor or people may be located outside of the track area. However, no part of the machine may leave the three-foot perimeter, nor should the machine cause any object to leave the playing arena such that it crosses the three-foot perimeter (either a projectile or track component). Any violations will result in a disqualification due to safety considerations.
30. Teams will remain constant for the duration of the project. The faculty has the right to remove or otherwise penalize disruptive members of any team.
31. Wanton destruction of the opposing devices, the competition arena, or competition components is strictly prohibited.
32. Offensive language is prohibited. If heard, the offending team will be disqualified.



33. Similarly, behavior inconsistent with the class code of conduct, as outlined in the syllabus, will result in the offending team being disqualified. This includes, but is not limited to, the harassment of or threatening comments or actions toward other competitors, contest judges, or other attendees of the contest.
34. “If you don’t play, you can’t win.” If a device does not make any noticeable movement, the device is disqualified from that round of competition.
35. The faculty’s rulings on any clarification or dispute of these rules are binding and final.

## **Version History**

- 02/26/19 – Initial posted version