ME 210 Winter 2019 Project

February 14, 2019

1 Introduction

Welcome to Westeros! The continent is aflame as the seven kingdoms duke it out to seize the Iron Throne. Two new houses have joined the fray, House Kenny and House Gumerlock, and are requesting your help in making their play in the game of thrones. It's time to bring some mechatronics to the swordfight! Castles will fall and cities will burn as you carry forward the flag of your house. But be warned, there are rumours that dragons have returned and are seeking to demolish all contenders for the throne.

The purpose of this project is to provide you with an opportunity to apply what you have learned so far in ME210 to solve an open-ended mechatronics design problem. The task is to design an autonomous war machine that will compete against an opponent in a miniature mechatronic siege.

Figure 1: Wildfire

2 Project Specifications

The objective of the battle is to score more points than the opposing House. Points are earned by (a) destroying the opposing Houses towers by knocking them over with wildfire (Nerf Ammo) and (b) successfully depositing wildfire into the belly of the Dragon. Your WARRIOR , Well-Aiming Really Really Intel-

ligent, but Obedient Robot, starts in the Throne Room without any wildfire, and must navigate to the Royal Armoury and push the Munition Receiver button to request wildfire. The House with the most points at the end of the 2:10 round wins.

2.1 The Arena

- The Arena is constructed from particle board uniformly covered with white laminate.
- The Arena consists of two identical 8' by 4' halves spaced 6" apart. A 4" tall wooden barrier encloses each half of the Arena. This barrier will prevent WARRIORs from departing from their territory.
- WARRIORs will commence play from their Throne Room, an 18" by 18" zone located at one end of the Arena. House's may choose their WARRIOR's starting orientation.
- Each half of the Arena has 3 towers located on the outer perimeter, as well as a King's Landing (also a tower) located in the center of the half-Arena.
- A tower is destroyed when $> 50\%$ of its mass is knocked over. Destruction of a tower is worth 1 point, though the difficulty of toppling each tower varies.
- Each House also has 1 Dragon, a moving target located on the outer side of the Arena. The Dragon will move along a horizontal track and then stop for 3 seconds, and then continue to move. You can keep the other House's Dragon at bay by shooting wildfire into the mouth of the Dragon for 2 points.
- Points are scored using wildfire. The wildfire are lightweight, closed-cell foam balls, with a mass of 2g and a diameter of approximately 4cm.
- Dragonstone, Winterfell, and the Dragon can be located by their associated infrared (IR) emitting Beacon with a tower-specific frequency. King's Landing and Casterly Rock do not have Beacons.
- Beacons are located 18" above the playing surface directly above (or in) a given tower.
- The Beacons are approximately omni-directional, and may be detected from anywhere on your side of the Arena when not impeded by the Wall.
- The Wall is a 1' tall and 5' long barrier between the two halves of the Arena. The Wall blocks access to towers and Beacons from certain angles, and is subject to destruction. No points are awarded for destruction of the wall.
- Each half of the Arena has a Royal Armoury from which your robot may request wildfires. The Royal Armoury is an 18" by 18" zone containing a Munition Receiver. When the Munition Receiver is depressed, your team may manually reload your WARRIOR with up to 6 wildfires.
- The Munition Receiver is a 3.5cm by 7cm rectangular piece hinged at the wall. The bottom of the piece is located 1" above the playing surface. To effectively trigger the Munition Receiver, the robot would therefore aim for a 3.5cm line that is 1" above playing surface.
- Lines of 1" wide non-reflective black tape lead from the Throne Room around the King's Landing to the Royal Armoury. A 1" wide line runs perpendicular to this path between at the midpoint of the Arena and the wall.

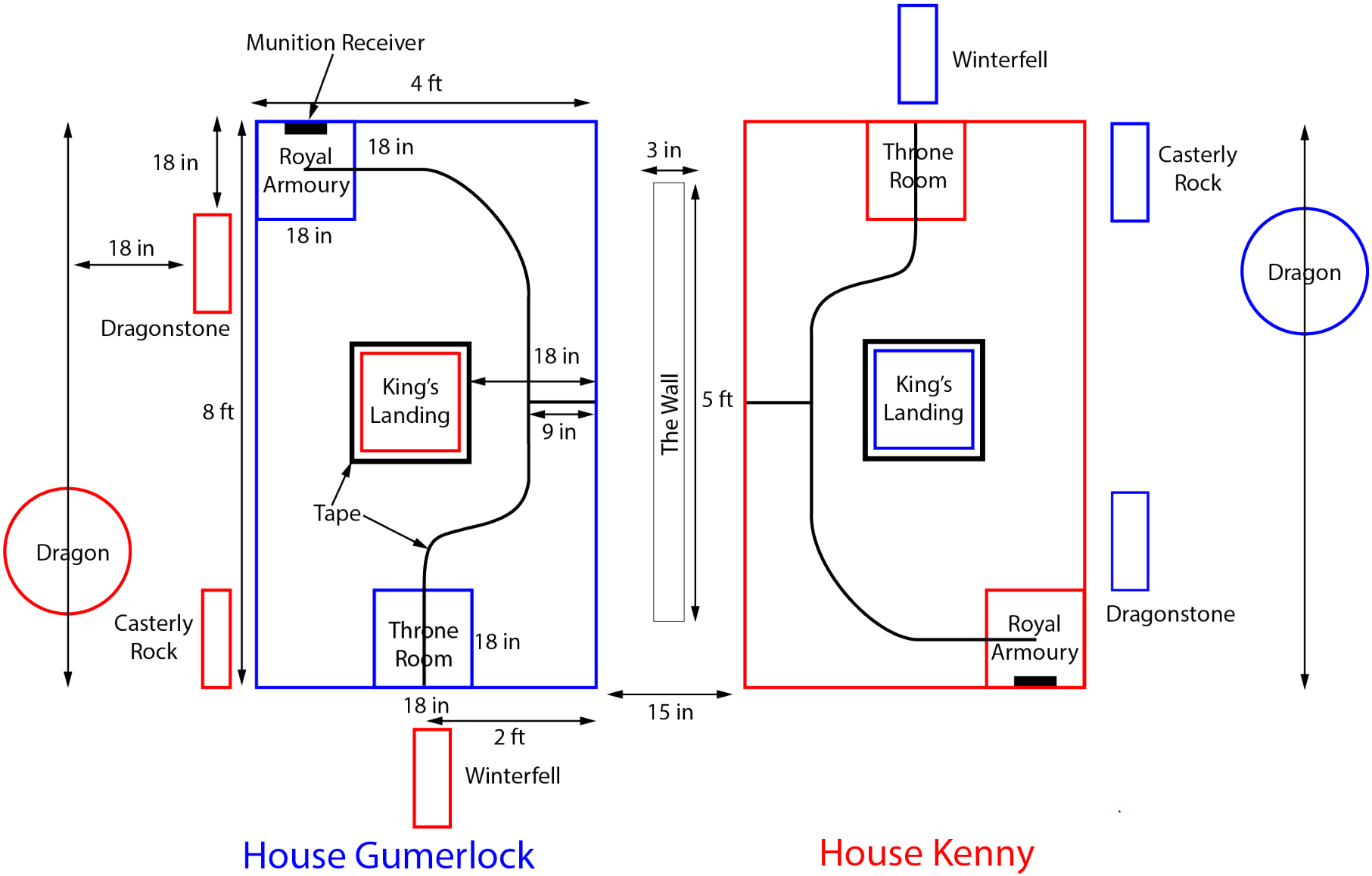

Figure 2: The Arena

2.2 The Towers

- There are four stationary towers (Dragonstone, Casterly Rock, Winterfell, and King's Landing) and one moving Dragon.
- The following table describes the dimensions and IR Beacon frequency of each tower:

Tower	Dimension (cm)			Beacon		
	Height	Base Width	Top Width	Red Freq (Hz)	Blue Freq (Hz)	Duty Cycle
Dragonstone	33	3	16	1150	1955	50%
Casterly Rock	39	8	4	N/A	N/A	N/A
Winterfell	42	2	2	1150	1955	33%
King's Landing	32	4 (2 bases)	16-32	N/A	N/A	N/A
Dragon	53.34	15.24	6	1150	1955	25%

- Beacons are held above Dragonstone, Winterfell, and the Dragon, and will remain in place when the tower collapses. Each Beacon is aligned with the central axis of its respective tower. Each Beacon is active when its tower is standing, and will turn off upon its destruction.

2.3 WARRIOR Requirements

- Each student team will be responsible for designing, building, and demonstrating a WARRIOR. The WARRIOR is an autonomous machine which will compete in the battle according to the specifications and rules defined in this document.
- Each WARRIOR must be a stand-alone entity, capable of meeting all project specifications, and must operate completely untethered during grading and competition.
- Power for the WARRIOR must be supplied by batteries, which are to be carried on board of each WARRIOR. Each team will receive two 7.2V NiMH rechargeable battery packs. Use of circuit breakers is mandatory. We will provide one circuit breaker which will allow you to start up motors (it accepts short current surges). Additional NiMH batteries may be used if desired, and may be purchased from the stockroom (depending on availability).
- The use of Li-ion, LiPo, and Lithium primary batteries is strictly forbidden.
- Each WARRIOR shall incorporate an easily accessible toggle switch on its exterior which will serve as an emergency stop switch. The switch must cut all power to the machine when toggled.
- At the beginning of each round, your WARRIOR must fit within a 12" x 12" x 12" cube. Your robot may be guillotined if it does not respect this rule.
- The WARRIOR's control software should be executed from the flash memory of one or more Teensy microcontrollers. Computers will not be permitted to be tethered to the WARRIOR during its operation.
- Each WARRIOR must be constructed as part of ME 210 activities during the remainder of the quarter. It may not be based on a commercial or otherwise preexisting platform. Rulings from a member of the teaching team may be requested if there are questions about the content of your WARRIOR.
- Each team must adhere to an expenditure limit of US $200 for the materials and parts used in the construction of

the project. The cost of the two provided NiMH battery packs, fuses/circuit breakers, and the lab kit components (including a single Teensy per team member) do not count towards this limit.

- WARRIORs must be robust to all normal game interactions including, but not limited to, collisions with any part of the Arena, stray wildfire, debris of fallen tower, and old, sad wildfire meandering aimlessly about the Arena.
- WARRIOR are limited to a maximum capacity of 6 wildfire obtained from the Royal Armoury at any given time.

Figure 3: House Gumerlock or Kenny??

3 Rules of Engagement

- Rounds last for 2:10. The House with the most points at the end of the round will be declared the victor.
- In the event of a scoring tie, the House which reached their final score first wins.
- WARRIORs must automatically cease game play 2:10 after the start of a round.
- Each WARRIOR is placed inside its team's Throne Room at the start of the game.
- The initial orientation of each WARRIOR may be decided by its House.
- An auditory start command will be issued by a member of the teaching team, at which time a member of each team will activate their WARRIOR thereby initializing game play. This is the last human interaction permitted with the WARRIOR until 2:10 has elapsed. The only exception is for reloading wildfire into the WARRIOR while it is at the Royal Armoury, and handling emergencies as determined by the teaching team.
- No information may be passed to your WARRIOR during the battle. This includes the method by which wildfire are loaded.
- WARRIOR must begin each round with no wildfire.
- WARRIOR may navigate to the Royal Armoury at any time to be reloaded with up to 6 wildfire by a human member of the House. WARRIORs must be completely within the boundaries of the Royal Armoury while reloading.
- No part of the WARRIOR may be within the boundaries of the Royal Armoury while launching wildfires or attempting to destroy any towers. If your WARRIOR launches a wildfire within the Royal Armoury, your Royal Armoury will be destroyed.
- Intentional destruction, damage, or alteration of any part of the Arena or other WARRIORs is expressly forbidden.

This does not include your own or your opponent's towers or the Wall.

- Intentional jamming of your opponent's sensing abilities is prohibited.
- WARRIORs and their respective Houses must show good sportsmanship: any celebratory actions or displays prior to the end of the game will be penalized, and we will be very, very disappointed in you.
- All machines and devices must be safe to users, to the lab, and to any spectators.
- The teaching team reserves the right to require your House to reduce your wildfire launch speed if said speed is considered unsafe.
- No part of the WARRIOR may become ballistic and leave the Arena. wildfire are not considered part of the WARRIOR.
- The competition seed position will be determined by the order in which Houses performed the graded check off (see performance requirements).
- Members of your House are not allowed to position themselves in a way that will interfere with the activities of the opponent's WARRIOR. Polite,"G-rated" heckling is permitted, of course.
- All projects shall respect the spirit of the rules, as established in this specification and in the culture of ME210. If you are considering something that may bend or violate the rules, you shall first consult with a member of the teaching staff. Interpretations and rulings are the sole domain of the teaching staff.

4 Performance Requirements

- For the purposes of grading, the minimum requirement for each WARRIOR is to start at Throne Room, drive to and successfully load at least one wildfirefrom Royal Armoury, and "beat a brick" by 1 point. This means that, in competition against a literal brick and within the specified 2:10, you must attain a net destruction of 1 enemy tower. If you destroy any of your own towers, you must knock down additional enemy towers in order to check off.
- Your team may check off at any time by declaring your wish to check off to a member of the teaching team prior to the check off attempt. If disaster strikes ("Its never done THAT before!?!!"), and your WARRIOR fails to check off, your House's check off requirement will henceforth be raised to two successive, successful check-offs. If either of these consecutive check-off attempts fails, you will be required to perform three successful checkoffs. **Check-off must be completed for all teams no later than 4:00pm on Friday, March 9.**
- It is important for everyone to remember that the minimum performance requirement is the goal for the class. Student teams are strongly encouraged to strive for demonstration of the minimum performance functionality as early as reasonably possible, so that the members of these teams may return to their regularly-scheduled lives.
- The results of the tournament held at the public presentation session will not affect grading. The public presentation is purely an opportunity for you to enjoy the devices you've created, and to show your friends and families why you have disappeared for 3 weeks.

5 Project Advice

- Start early (now, start now).
- Spend a lot of time perfecting your state machine, hammering out your design, agreeing on your interfaces, and picking your components. These will be the foundation for your code, and programming your robot will go a lot faster if you do these things well.
- Get out of your comfort zone. If you don't have experience with a concept or device, working on it during the project will be a great learning opportunity. For example, if you are a CS major, do not spend all of your time coding; instead work on signal conditioning or mechanical design.
- Work together and communicate. It's tempting to divide and conquer, but your teammates can't help you if they don't understand what you're working on.
- Sleep. You think you'll get more done if you stay up for 48 hours straight beating your head against a stack of datasheets, but you're wrong.
- Know where to find emergency replacement parts. If you don't have time to wait for a shipment, Jameco, Fry's (did you know Fry's will haggle prices?), and room 36 can save your project, for a price (be wary of, but receptive to, blood contracts).

6 Essential Guidelines for Safety

- **All projects shall respect the spirit of the rules, as established in this specification and in the culture of ME210. If you are considering something that may bend or violate the rules, you must first consult with a member of the teaching staff. Interpretations and rulings are the sole domain of the teaching staff.**
- All machines and devices must be safe to users, to the lab, and to any spectators.
- High speed projectiles are not permitted; if your WARRIOR launches wildfire, they should not be traveling fast enough to cause bodily harm.
- The powers of the Teaching Staff to protect ME210 and its participants are very substantial and shall not be questioned.
- Tolerances on the dimensions of the Arena are ± 1 inch unless otherwise specified.
- Once the Arena is constructed, its dimensions supersede the above tolerances.
- Although ungraded, teams are encouraged to use creative themes and aesthetics for their WARRIORs and themselves.
- Pyrotechnics and combustion of any kind are prohibited.
- A main circuit breaker/switch will be provided and must be used as a main power shut down. When the switch is in the off position, all power must be disabled, and no subsystems may remain energized.

7 Evaluation

Concept (25%):

The Concept portion of your grade will be based on the technical merit of the design and programming for the machine. Included in this grade will be evaluation of the appropriateness of the

solution, as well as innovative hardware and software and use of physical principles in the solution.

Implementation (25%)

The Implementation portion of your grade will be based on the machine displayed at the evaluation session. Included in this portion of the grade will be evaluation of the physical appearance of the machine and the quality of its construction. Aesthetics will not be judged, rather, craftsmanship and finished appearance are the focus of this portion.

Performance (25%)

The Performance portion of your grade will be based on the results of the performance during the check-off evaluation session.

Coach Evaluations (10%)

The Coach Evaluations portion of your grade will be based on the four project milestone reviews (see table below).

Report (15%)

The Report portion of your grade will be based on an evaluation of the final report. It will be judged on clarity of explanations and on the completeness and appropriateness of the documentation. This report should be prepared in HTML format (as a website), and submitted as a compressed ZIP archive on Canvas ready for publication on the Internet.

8 Project Milestones

EVENT	DELIVERABLES
Project Assigned 2019-02-14 (in class)	Finalize a four person team, and enter your info into the team spreadsheet.
First Review 2019-02-19 (in class)	*2-4 minute in-class presentation.* Show 3 design concepts with sketches, time schedules, project plan, and personnel assignments.
Second Review 2019-02-26, 23:59	*Turn in physical documentation* on Canvas, including schematics, state diagrams, design calculations, and any preliminary testing results.
Third Review By 2019-03-01, 23:59	*Demonstration of all functional subsystems per block diagram*: ball launching, beacon sensing, tape sensing, navigation, etc. Presented to coach; check-off by teaching staff.
Fourth Review By 2019-03-08, 23:59	*All subsystems functional and integrated.* Beat The Brick check-off by teaching staff.
Project Presentations 2019-03-10, 19:00	*Public presentation and tournament in the 550 Atrium.* Guests welcome! Finished, presentable, competition-ready machines.
Project Review 2019-03-12 (in class)	*Brief in-class presentations* from each House on project outcome and lessons learned. Bring your WARRIOR!
Project Report 2019-03-15, 23:59	*Report in HTML format*, suitable for publishing on the ME210 website.