Project Proposal

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I. Introduction

The purpose of this project is to build a robot that will be sent to the SoutheastCon student competition in Orlando, Florida. This robot will represent Tennessee Technological University to schools around the Southeastern United States.

The team is tasked with creating a robot which will complete assigned tasks autonomously without direct control by outside devices. The way that points will be awarded has been defined with rigor and we have developed a strategy to best exploit the point availability, as addressed in this proposal. This project is a culmination of the Electrical Engineering, Computer Engineering, and Mechanical Engineering subject matter.

The objective of this project is to develop the team member's skills in systems engineering, engineering project management, and project design and execution principles using a practical engineering project. Last year, 22 schools participated in the student competition, so this is a great opportunity to advertise the College of Engineering at Tennessee Tech regionally to employers and to other universities.

The following project description clearly defines the scope and expectation and then defines the constraints or "shall statements" from the scope.

II. Domain and Background

The goal of this project proposal is to describe specific goals, scope, and metrics for success for the SoutheastCon Hardware Competition robot which will be taken on as our capstone project for the 2022 - 2023 academic year.

This project is being taken on by a cross-functional team with collaboration between the Electrical and Computer Engineering and Mechanical Engineering Departments at Tennessee Tech University.

A. General

The setting for the IEEE SoutheastCon Hardware Competition: At the IEEE theme park, Duck Gardens, a cyclone caused significant damage and left some animals trapped. The ducks were pushed out of the duck pond by the cyclone, which also toppled over the three duck sculptures. The park also has manatees and alligators, which are safe, but hungry. Duck Gardens requires robots capable of assisting animals, cleaning up, and rebuilding. The robot's tasks include feeding the manatees and alligators, relocating the ducks to the pond, rebuilding the statues, or a stack of pedestals, depositing the broken parts in the recycling bins, and shooting animated fireworks for the finale after round completion.

Points that are available in this competition are broken down in Figure 6, but the point objectives that we are attempting to obtain more specifically are delivering food chips to the alligator and manatee aquarium for seven points a piece, placing all 10 ducks in the center duck pond for 5 points a piece, stacking a three pedestal tall statue in a white inner circle near the starting area for a point amount to be released in an upcoming revision to the rules, and stacking two pedestals on the white inner circles near the starting area for 18 points.

III. Formulated Problem Statement

A. General

This project is taken on annually by the Electrical and Computer Engineering Department at Tennessee Technological University.

An autonomous robot will need to be designed that meets design specifications outlined by the Institute of Electrical and Electronics Engineers (IEEE) and the Hardware Competition Chair, Stephen Hopkins, in the Hardware Competition Rules [1]. The robot should be able to fit within the 1'x1'x1" starting area adjacent to the duck pond at the beginning of the match. Players will have two minutes prior to starting the match to prepare their robot and arenas for the match. Every task which will gain points must be completed within the three minute time constraint.

B. Arena Description

The arena measurements are defined in the hardware competition specification document, and an image of the arena is shown as Figure 1.

The arena is a 8' x 4' rectangle. The starting area is a one square foot area at one of the walls of the arena. It is denoted by a white square on Figure 1.

The duck pond is 14" in diameter. The arena has a single duck pond with an inner circle in the middle of the pond. The inner circle, which is a statue location, measures 4" in diameter. The white circle thickness is 1".

Two more statue location circles are on either side of the starting square. These are denoted on Figure 1 by the white circles near the starting area, or the large white rectangle. The edges of the circles are 6.5" away from the starting rectangle.

The manatee and alligator aquarium measures 9" x 12". Those are shown on the left hand side of the arena with the manatee aquarium shown as a green square and the alligator aquarium shown as the red square.

The arena has two recycling areas and each recycling area is 18” x 12” in each corner of the right side of the park. The recycling area is painted with diagonal white lines.

One specific distinction that should be made is when the word inner ring is used, the inner rings refer to the 4” smaller white rings in the arena of which there are three, two on either side of the starting area and one in the center of the duck pond.

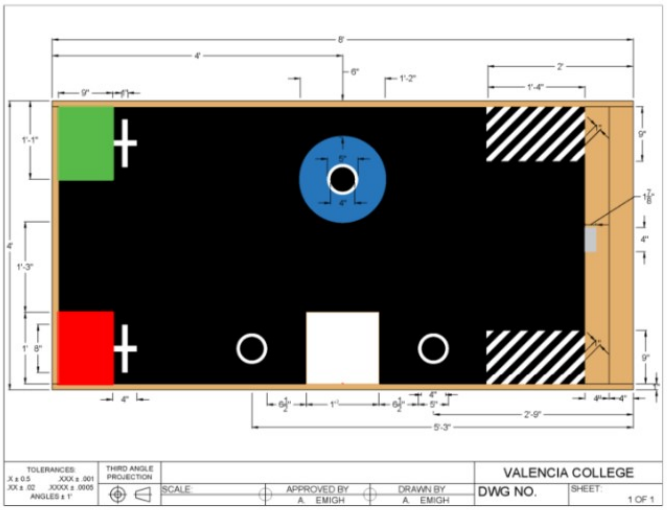

Fig. 1. Playing Board [1]

C. Competition Overview

There are ten ducks at the theme park, and one of the ten is a pink duck. The robot needs to bring the ducks back to the pond, and can place the pink duck on top of the reassembled statue for more points.

Fig. 2. Duck Object [1]

The statues must be rebuilt by the robot. Seven pedestals are in the arena and must be stacked by the robot. Statues can be two or three pedestals tall, and different point quantities are awarded for statues stacked with two or three pedestals. The point allocations are based on the location and if a duck is stacked on top, outlined in Figure 6. The arena has three white pedestals, two green pedestals, and two red pedestals. The color configurations are defined in Figure 6, and the team can receive extra points for stacking a three tall statue with white, green, and red pedestals from the bottom to the top. Points can also be obtained by stacking pedestals in any color order to create statues, but this results in less points.

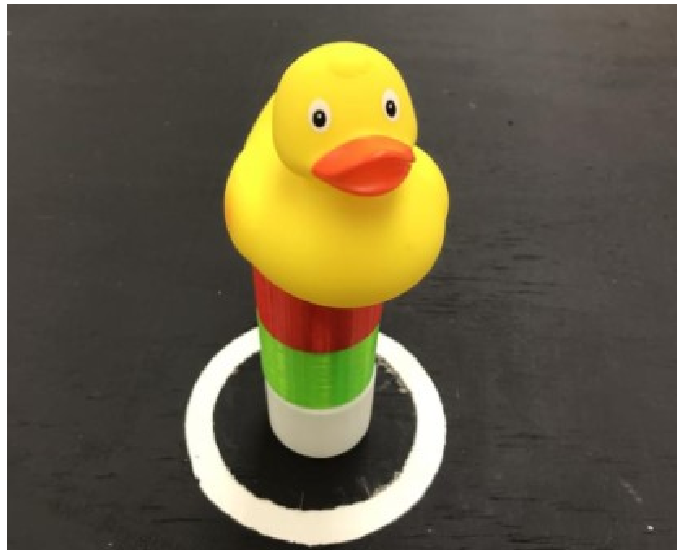

Fig. 3. Statue With A Duck On Top [1]

Fig. 4. Duck Pond [1]

Another task is to feed the alligators and manatees in their designated aquariums the correct color food chips. Each team will be provided with three green and three red food chips for the manatees and alligators respectively, and these will be placed next to the robots starting position. The food chips can be preloaded into the robot by one of the team members during the setup phase. Game points will be awarded for feeding food chips successfully to either animal, but more points will be awarded for feeding the correct food chips to the correct animal.

After completing each task, all unused items can be placed in the recycling area for additional points. This area is used to dispose of items that were not used in previous tasks from the field, if there are any unused items.

The last objective is the fireworks display. The theme park has a daily fireworks display to signify the end of the day. Activating the display will define the end of the round. There will be a horizontal switch that is to be connected to a Raspberry Pi and a computer monitor. The switch, when flipped, will run the program on the Raspberry Pi to play a five second fireworks video. The code may be in Python or Java, and must run on the Raspberry Pi. The video file format must be MPEG. Duck Gardens will provide a complimentary fireworks video if the team chooses not to make one; however, higher points will be awarded to videos based on creativity, clarity, and production quality.

IV. Solution Statement

A. Timeline Approach

The solution will be developed based on the general problem statement, constraints, and the below shall statements.

The team has analyzed value versus difficulty for each of the tasks and assigned a numerical ranking to each task in weekly meetings which include the team of electrical, computer, and mechanical engineers. This ranking is shown in Table 1, which the team unanimously agreed upon early in the planning process. The value is based on the number of points that the task can feasibly receive. In the appendix, there is a table called figure 6, including each task and its assigned points for completion. This will drive our focus throughout the semester and keep us focused on the most valuable tasks. The team has completed literature review on what has worked in the past for robot design. In this phase the team has gained valuable insight into the field of robots and the existing tools and libraries that are available for us to use in design. The team will then begin the top-level design phase and start using top-level systems analysis techniques to design abstract subsystems that the team knows can communicate and work well with each other in a larger system.

	Value (1-5)	Difficulty (1-5)	Rank (1-5)
Manatee and Alligator	5	2	2
Duck Pond	3	4	1
Recycling	1	1	5
Fireworks	2	2	4
Statues	4	5	3

TABLE I
Value versus Difficulty Analysis for Each Objective

After top-level design, the subsystems will begin to be broken down into atomic tasks by team members that have a background in a given focus area. Each team member is expected to communicate with the team what objectives are being completed and to reveal any blockers that are being faced.

Before the end of the first semester (Fall 2022), we should have at least 50% of the design completed and 25% of the parts ordered, specifically those that are hardest hit by the current supply chain shortages.

Following the holiday break in December and January, the team will have two weeks to have a final detailed design proposal completed. This should consist of the final design constraints and objectives, and will be our blueprint for the manufacturing stage of the project.

During the second semester (Spring 2023) of capstone, the team will focus early on detailed design and most on manufacturing the robot from the technical specifications laid out in the first semester and early second semester.

The event will take place on April 13th-16th in Orlando, Florida. All design and manufacturing must be done by the competition date in order to participate successfully in the competition.

The timeline attached in the appendix outlines the overall timeframe we expect to adhere to for this project. The specific dates are not confirmed for the second semester of capstone, but the dates shown in the table are accurate within +/- seven days.

B. Existing Solutions

Automated guided vehicles are load carriers or material handling systems that move themselves around their environment without a driver or operator on board. Automated guided vehicles come in many different varieties. While many AGVs resemble conventional human-driven vehicles, they are made to run without any guidance or direct human input [2]. This research provides a definition of Automated Guided Vehicles (AGVs) and the types, how they work, and why these AGVs should be considered as viable options for use in this project.

An AGV, automated guided vehicle, is a system which follows a predestined path around its environment and is a mechanical vehicle which carries a load [3]. Moreover, they are self-propelled vehicles in which the motion is controlled by sensors and software. Most AGV types follow predetermined paths and rely on fixed navigation techniques like magnetic tape or cables. For example, Automated Guided Carts, Forklift AGVs, Unit Load Handlers, and Towing AGVs. However, there is another type of AGVs that feature more advanced tech with dynamic navigation capabilities, these are called autonomous mobile robots (AMRs). Navigation is the capacity of the mobile robot to locate itself.

By sending input signals to its drivers, actuators, and effectors, a robot may carry out the intended, or programmed, sequence of operations. This is known as motion control. The control system for mobile robots is frequently a closed loop. Proportional-Integral-Derivative (PID) control, a type of feedback control, is the most widely used closed-loop control in robotics. Through continually monitoring parameters both internally and externally, feedback control enables the robot to fix any disruptions or inaccuracies in its course. The PID controller mathematically represents the error signal as well as the proportional, integral, and derivative gains to enable the controller to reduce the mistake quickly while keeping a steady signal and preventing overshoot.

Finally, the team will demonstrate how AVGs will aid in achieving the project's requirements. Automatic Guided Vehicles are used in assembly, kitting, transportation, staging, and order picking. These features can help with the project's requirements. Assembly in AVGs is moving products and kitting in AVGs is collecting parts for assembly.

1) The Automatic Guided Vehicle's features can help complete the project's requirements by moving or collecting the ducks of different colors.
2) The Automatic Guided Vehicle's features can help complete the project's requirements by rebuilding the statues by taking and loading the specific statue then delivering it to the correct place.
3) The Automatic Guided Vehicle's features can help complete the project's requirements by feeding the manatees and the alligators. Also, it can help to pick up ducks and place them in the pond. When applied to the "recycling", the AVGs can move the remaining pieces to the recycling bins.

C. *Outline of Strategy*

A general strategy has been discussed after examining previous solutions to similar problems and reviewing the SoutheastCon Hardware Competition rules. The following strategy is still subject to change, as the finalized rules have not been posted as of the writing of this document.

The specific technical algorithms that will be used to path track and plan has not been determined, but a motion planning algorithm will be essential. The plan around how the robot will move around the arena is that it will sweep through the arena, almost like you would mow your lawn, while picking up items in its path. Items picked up will be sorted into holding areas for ducks or for pedestals either through a mechanical means based on shape or by the use of sensors. The sweeping will require some overlap in order to cover the entire floor space. The team will also design the route so that it will always finish sweeping near a recycling area, so that the robot can dispose of any unused pedestals. After this, the robot will be required to make direction calculations to deliver specific items to their destinations, all of which are covered below in the duck and statue placement sections.

The competition rules define that multiple robots can be used, but they must all be contained within the 1'x1'x1' robot starting size requirement and start in the white starting square. The team plans on building multiple bots, one larger robot and one or more "microbots". The microbot or microbots will be tasked with feeding the alligators and manatees in parallel with the larger robot's work on the other tasks.

The strategy developed for finding, moving, and placing ducks includes the following: moving around the arena using a mapping algorithm and positional planning similar to that described earlier, picking up the ducks in the arena using a mechanical system and storing them in either an internal or external storage location, and then using direction calculations and mapping algorithms to get back to the duck pond to place the ducks back to their home pond.

The strategy for finding, collecting, and building pedestals into statues is as following: moving around the arena using a mapping algorithm the same as that described earlier, picking up the pedestals in the arena using a similar mechanical system to that for the ducks, and stacking the pedestals internally in a silo or similar storage container so that they can be stored in a stacked orientation, and then building the statues by placing them with the silo-like system on the robot. The strategy will be to build one statue of three pedestals, build one statue of two pedestals, and to disregard the sixth and seventh pedestals in the recycling area if they are found and picked up before the end of the round. This process is covered in the next paragraph.

The recycling area, as discussed in our meetings, has had less focus put on it. The plan is to collect every item that is in the path taken by the robot, and deliver it to the correct location for a larger point allocation. The only exception to this is if we see the sixth and seventh pedestals, because we only need five pedestals to build two statues, one being three pedestals tall and another being two pedestals tall, the sixth and seventh pedestals will be thrown in the recycling area. The sixth and seventh pedestals are the only plan to use the recycling area during the competition.

The animated fireworks show serves as the finale for the round of the competition and is activated by flipping a switch to the right. This switch flip activates a Python or Java script written by the team that will display an animated fireworks display MPEG video. This video can be created by the team and will be scored based on clarity, creativity, team spirit, and the production quality or it will be provided at the competition.

D. *"Shall" Statements*

Shall design an autonomous robot with a single start button, allowing the robot to start moving through its environment.

The robot will have a single emergency stop button at a point that is easily accessible and can be safely reached, which will shut down all physical movement performed by the robot in the case of an emergency.

Shall have a self-latching emergency stop push-button that has a positive operation. The button shall not be a graphical representation or a flat switch based on NFPA 79 - 10.7.2. [4]

Shall design an autonomous robot that will earn all possible points for delivering the correct food chips to the manatees and alligators.

Shall design a robot which can find and move 90% of the ducks into a holding area connected to the robot.

Shall locate the duck pond in the center of the arena within plus or minus one inch of error tolerance.

Shall transport and place 90% of the ducks stored inside the holding area to their final location in the duck pond.

Shall design an autonomous robot that will be able to flip a switch from left to right.

Shall design an animated fireworks MPEG video and write a Python script that will play the video when activated by the switch.

Shall find and move at least five pedestals into an internal holding area inside the robot.

Shall assemble one statue that is three pedestals tall and one statue that is two pedestals tall using all five pedestals obtained in order to maximize points obtained based on discussion in weekly meetings.

Shall place statues entirely inside the white inner circles within plus or minus one inch of error tolerance.

Shall place remaining unused pedestals that are held after the five required pedestals have been obtained within the internal holding area inside the robot.

Shall move the extra pedestals obtained over the five required pedestals in the recycling area.

Shall abide by the Department of Energy Standard 79 FR 7845 in our purchase or design of wall warts for energy conservation and efficiency. [5]

V. Obstacles and Unknowns

The first obstacle that is immediately noticeable is that this is, to the team's knowledge, the first time that a cross-departmental team has been built for a Capstone/Senior Design project that requires so much communication and cross-functional relationship building to reach the evaluation success metrics. The team hopes to use this to everyone's benefit and ensure that we lead each other and have a common vision between the electrical and computer engineering (ECE) and mechanical engineering (ME) teams.

The ongoing global supply chain and chip shortage might also cause problems for receiving our ordered parts on time as needed, but this will be addressed by ordering parts as early as practical, checking lead times in order to make proper choices on where to order parts from or looking for viable replacement parts.

Several of the team members have prior experience in robot-building, but many do not have that application experience from participating in past robotics competitions. The team does however have extensive knowledge in all required courses in the ECE and ME curriculum between freshman and junior years. This knowledge will be used to address this lack of robotics experience and will also allow the team to come to the problem solving table with a fresh perspective on how to approach issues being faced.

Things that are anticipated to be needed to address these obstacles include regular team meetings with our cross-functional partners in the mechanical engineering department, meetings with subject matter experts on campus to discuss high-level approaches and the practicality of those approaches (professors, grad students, etc.), finding an engineering partner on campus that can help the team with the top-level application and manufacturing side of the project (someone in the machine shop, staff engineer at university, etc.), and subject matter research on successful implementations of hardware competition and commercially available robots which have worked well in the past. We will of course need and are required to have weekly meetings with our advisor, Mr. Jesse Roberts, to ensure that the project remains on track and to ask questions related to the project.

VI. Measures of Success

This section will guide the team in determining whether the overall project is a success. Success will be determined based on the trials conducted before the competition. Each functionality will be tested out of ten trials to measure the success of that functionality. Each individual task will have an assigned number of successful trials out of ten to determine whether it was a success.

The robot must be able to be turned on by the LED light indication every time as well as be turned off by a single emergency stop button. Success will be based on if the bot turns on/off with the LED light indication ten times out of ten trials.

The robot must be able to successfully deliver each correct food chip to the correct animal nine times out of ten trials.

The robot will be successful if the robot can find and move 90% of the ducks into an internal holding area, locate the duck pond in the center of the arena within plus or minus one inch, and place 90% of the ducks stored into the duck pond nine times out of ten trials.

The robot must be able to flip a switch from left to right that activates a Python script that will play the created fireworks video nine times out of ten trials.

The robot must find and move at least five pedestals into an internal holding area inside the robot in nine of the previous ten trials.

The robot must assemble one statue that is three pedestals tall and one statue that is two pedestals tall using the five pedestals obtained.

The robot must place all statues entirely inside the white, inner circles within plus or minus one inch nine out of the previous ten trials.

The robot must be able to place any remaining pedestals that are held inside the internal holding area into the recycling attraction nine out of the previous ten trials.

VII. Project Design Methodology

This section is meant to outline top-level design approaches for this project and not specific subsystems that will be built.

Design a fully autonomous robot that will be able to see and interact with the world around it using artificial intelligence and algorithms. The team will assign task's priority based on difficulty and the points available.

The team will use a systems approach, similar to the methodology outlined in the NASA Systems Engineering Handbook, to the design of the robot and its subsystems.

The team will use the top-down design approach to the project, starting with higher level design and then delving into technical design for each subsystem. The team will constantly be refining the process as the team members get deeper into technical problem solving.

VIII. Broader Impact

This robot will represent the Electrical and Computer Engineering Department and Mechanical Engineering Department of Tennessee Tech University on the regional level to other universities around the Southeastern United States. This representation could potentially affect how others view our school and our fellow classmates. Our stewardship of the title of the Tennessee Tech IEEE Chapter with the addition of a successful performance could make a difference on which students decide to pursue their education from our engineering program. It could also attract new potential employers who had never considered hiring students from Tennessee Tech to consider recruiting students from our program. This competition could reveal new opportunities for students that did not even participate in the competition.

Other than just social impacts, this project could prove to have some ethical impacts as well.Any machine or robot with any sort of movement mechanism could cause safety concerns via human error, mechanical failures and improper insulation around any hot electrical wires. It will need to have fail safes within the programming of the tasks to ensure the safety of everyone involved.

The environment could be negatively affected by the robot. Battery waste when not disposed of properly can cause damage to wildlife in the area where it is disposed. The batteries could start to break down and leak battery acid onto the ground or even into a body of water.

IX. Technical Overview

A. Control System

A control system is necessary for any autonomous robot. This system will be the "brains" of the robot that allows it to complete its tasks. This system will make most, if not all, of the decisions or computations the robot has to make. The control system will either be implemented by some kind of microcontroller or other embedded computer system. The controller will be the main line of communication to each of the other electrical subsystems that require communication from the controller such as the vision, motor, and power systems. Programming knowledge of embedded systems, communication protocols, and artificial intelligence algorithms may be needed for this system.

B. Computer Vision

A central vision system will be required for this autonomous robot. This vision system must be able to detect objects on the field. This system will require both a microcontroller to act on the sensor data and actuators to perform actions in the real world. The software for this system will need to analyze what is being detected by the sensor and send that data to the control system to make a decision based on data. For example, localization on the playing field, and also possible image processing of the environment. Skills needed for this subsystem are programming skills, networking skills, and knowledge of robot localization hardware.

C. Motor system

This system will be responsible for any kind of mechanical movement the robot will need to take. The inputs to this system will be what is received from the sensors and decoded by the control system. Motors will be needed most of all to move the robot and any other external movement such as arms, trays, bins, conveyors, etc. The specific motor drive design has not been fully decided on, however the wheels will most likely be omnidirectional. The skills needed to design this system are a knowledge of electromagnetic fields concepts as well as a general knowledge of electric power systems. The power system will need to supply the motor system with adequate DC voltage and current levels in order for the electric motors to function. The exact values of current and voltages needed for this subsystem are unknown at this time.

D. Power system

The robot will need a power system to supply all of the necessary DC voltages to each subsystem of the robot. The power supply needs to be a battery that can be charged through a wall wart as per the competition guidelines. The exact size of the battery, voltage rating and current rating will need to be decided later once a more detailed design has been created, and the team knows how much voltage and current needs to be supplied to each subsystem. Proper safety measures will also be put in place so that the bot all motion will be stopped by a single press of a button. Any and all safety measures must be tested for proper functionality in case of a major system failure. Each circuit will need to be properly grounded for safety purposes. Insulation, over-current protection in the form of devices like fuses, and voltage regulators will also be necessary to ensure the safety of everyone involved on this project as well as the subsystems of the robot. The skills required for this subsystem is a knowledge of electrical power circuit design as well as knowledge of electrical safety.

E. Chassis

The robot chassis must adhere to all guidelines set by the IEEE SoutheastCon Hardware Competition Guidelines document [1]. It must fit within one square foot. This system is essential and will be mainly designed by the mechanical engineering team. The chassis design will be greatly affected by the electrical requirements of the robot and a lot of communication between the mechanical and electrical team will be required for the chassis design and for all of the other subsystems on the robot. This means that the chassis will need to be a consideration and is a major constraint on the design of every other subsystem within the robot.

X. Project Feasibility

In this section, the projects required materials and personnel are outlined and a cost breakdown is covered. In terms of personnel, the team consists of five electrical and computer engineers and three mechanical engineers. The number of team members causes a constraint on the team, addressed by the following. Having only eight team members, the team must carefully align the timeline with the due dates of each assignment and the final due date for the project. Working in parallel with each other on separate portions of the project will be necessary to complete this project. The team has planned a tentative schedule for the planning, design, testing, and implementation that will ensure that the project is done in a timely manner and in an order that makes sense.

Materials and finances are also a factor in the feasibility of this project. The team needs to have a realistic budget, but also ensure they have everything they need for success. A cost breakdown is shown below in Figure 5.

SoutheastCon Robot 2022 Requirements & Budget			
	Qty	Unit Cost	Cost
Controller			
Microcontroller	2	\$20-\$40	\$40-\$80
		Total Cost:	**\$40-\$80**
Vision System			
Object/Landmark Detection	N/A	N/A	\$50-\$200
		Total Cost:	**\$50-\$200**
Motor System			
Brushless Motor	4-6	\$5-\$25	\$20-\$150
Servo Motor	3	\$10-\$20	\$30-\$60
Motor Controller	2	\$10-\$20	\$20-\$40
		Total Cost:	**\$70-\$250**
Power			
Switch	2	\$40-\$60	\$80-\$120
Toggle Switch	2	\$1-\$5	\$2-\$10
Fuse	N/A	\$1-\$4	~\$8-\$32
Wiring	N/A	\$20-\$40	\$20-\$40
Power Controller	2	\$10-\$50	\$20-\$100
		Total Cost:	**\$130-\$302**
Chassis			
Acrylic	3 ft²	\$10/ft²	\$90
3-D Filament	N/A	\$25-\$45	\$25-\$45
Epoxy	N/A	\$25-\$50	\$25-\$50
		Total Cost:	**\$140-\$185**
General			
Misc Components (resistors, capacitors, etc.)	N/A	N/A	\$80
Light activated switch	1	\$20-\$25	\$20-\$25
Game Board Construction Materials	N/A	\$100-\$200	\$100-\$200
Raspberry Pi for Arena	1	\$40-\$60	\$40-\$60
		Total Cost:	**\$240-\$365**
	Total Before Error:		\$670-\$1,382
Error Margin/Redundancy			50%
	Grand Total:		**\$1,005-\$2,073**

TABLE II
REQUIREMENTS & BUDGET BREAKDOWN

XI. CITATIONS

REFERENCES

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XII. Appendix

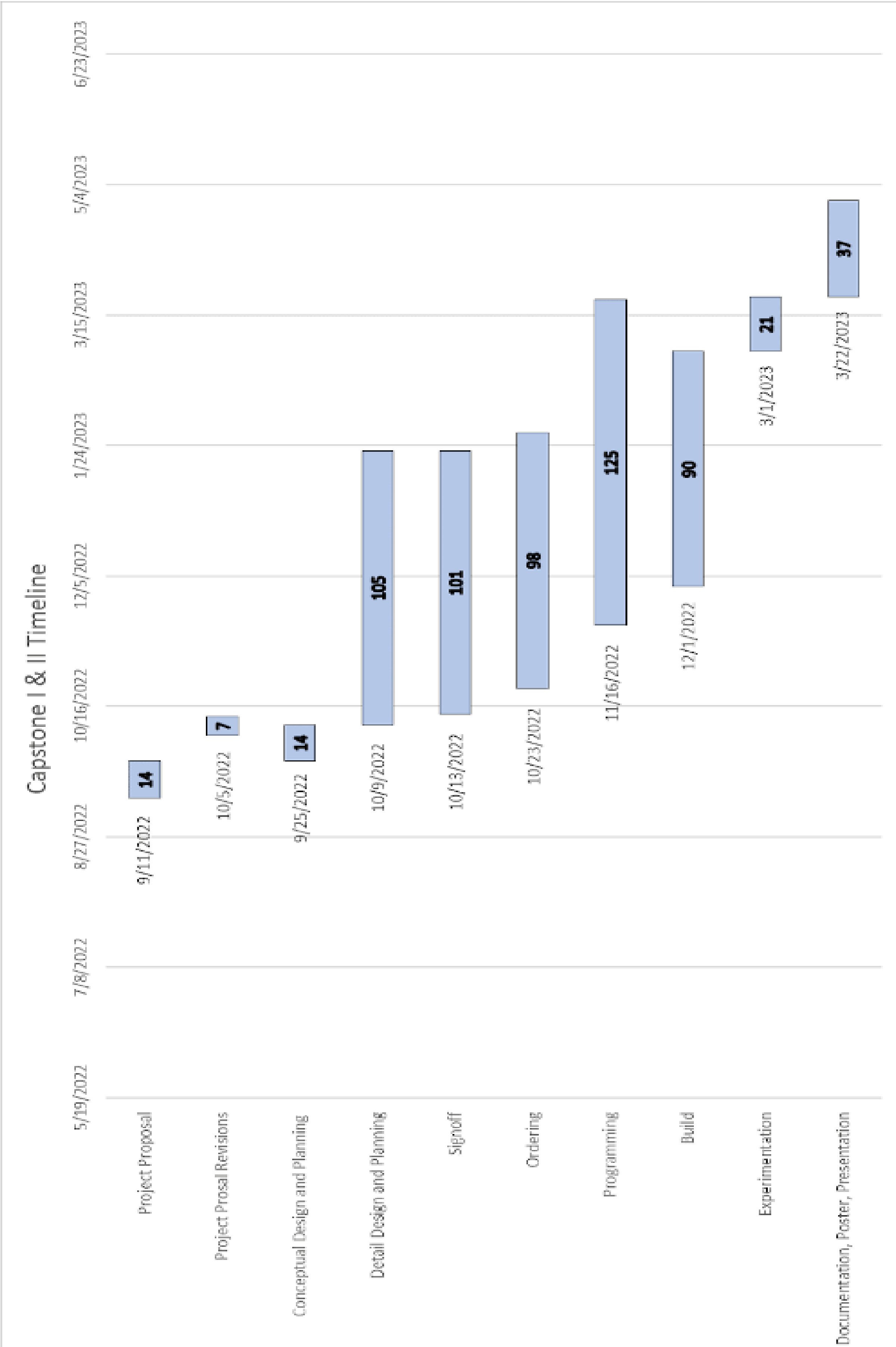

TABLE III
Timeline for Capstone I and II

Points	Task
36	Three pedestals stacked on the duck pond statue location inside the inner circle and in the correct order (base level – white, second level – green, third level – red) with a pink duck on top
33	Three pedestals stacked on the duck pond statue location inside the inner circle and in the correct order (base level – white, second level – green, third level – red) with a yellow duck on top
30	Three pedestals stacked on the duck pond statue location inside the inner circle and in any order with a pink duck on top
27	Three pedestals stacked on the duck pond statue location inside the inner circle and in any order with a yellow duck on top
27	Three pedestals stacked on the duck pond statue location inside the inner circle and in the correct order (base level – white, second level – green, third level – red)
24	Three pedestals stacked on the duck pond statue location inside the inner circle and in any order
24	Three pedestals stacked on the duck pond statue location inside the outer circle and in the correct order (base level – white, second level – green, third level – red) with a pink duck on top
21	Three pedestals stacked on the duck pond statue location inside the outer circle and in the correct order (base level – white, second level – green, third level – red) with a yellow duck on top
18	Three pedestals stacked on the duck pond statue location inside the outer circle and in any order
18	Three pedestals stacked on the duck pond statue location anywhere in the park and in the correct order (base level – white, second level – green, third level – red) with a pink duck on top
15	Three pedestals stacked on the duck pond statue location anywhere in the park and in the correct order (base level – white, second level – green, third level – red) with a yellow duck on top
12	Three pedestals stacked on the duck pond statue location anywhere in the park and in any order
30	Two pedestals stacked on a non-pond statue location inside the inner circle and in the correct order (base level – white, second level – green) with a pink duck on top
27	Two pedestals stacked on a non-pond statue location inside the inner circle and in the correct order (base level – white, second level – green) with a yellow duck on top
24	Two pedestals stacked on a non-pond statue location inside the inner circle and in any order with a pink duck on top

21	Two pedestals stacked on a non-pond statue location inside the inner circle and in any order with a yellow duck on top
21	Two pedestals stacked on a non-pond statue location inside the inner circle and in the correct order (base level – white, second level – green)
18	Two pedestals stacked on a non-pond statue location inside the inner circle and in any order
18	Two pedestals stacked on a non-pond statue location inside the outer circle and in the correct order (base level – white, second level – green) with a pink duck on top
15	Two pedestals stacked on a non-pond statue location inside the outer circle and in the correct order (base level – white, second level – green,) with a yellow duck on top
12	Two pedestals stacked on a non-pond statue location inside the outer circle and in any order
12	Two pedestals stacked on a non-pond statue location anywhere in the park and in the correct order (base level – white, second level – green) with a pink duck on top
9	Two pedestals stacked on a non-pond statue location anywhere in the park and in the correct order (base level – white, second level – green) with a yellow duck on top
6	Two pedestals stacked on a non-pond statue location anywhere in the park and in any order
2	Placing a duck, food chip, or pedestal in the recycling attraction
7	Each correct food chip fed to the manatees
7	Each correct food chip fed to the alligators
3	Each incorrect food chip fed to the manatees
3	Each incorrect food chip fed to the alligators
5	Each duck in the pond
3	Each duck, chip, or pedestal in a recycling area
10	Start the fireworks
10	Auto-start feature used and successful

Fig. 5. Scoring for Southeast Con Competition [1]