Project Proposal

Team 2: Nathan Gardner, Madison Kelly, Fatima Al-Heji, Luke McGill, Mark Beech
Electrical and Computer Engineering Department
Tennessee Technological University
Cookeville, TN
sngardner42@tntech.edu, mmkelly42@tntech.edu, fnalheji42@tntech.edu, lbmcgill42@tntech.edu, mlbeech42@tntech.edu

I. Domain Background

The goal of this project proposal is to describe our broader goals for the SoutheastCon Hardware Competition robot which will be taken on as our capstone project for 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 following is a description of 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. The Duck Gardens require 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, reassembling the sculptures, depositing the broken parts in the recycling bins, and shooting animated fireworks for the finale after course completion.

II. 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].

B. Playing Field Description

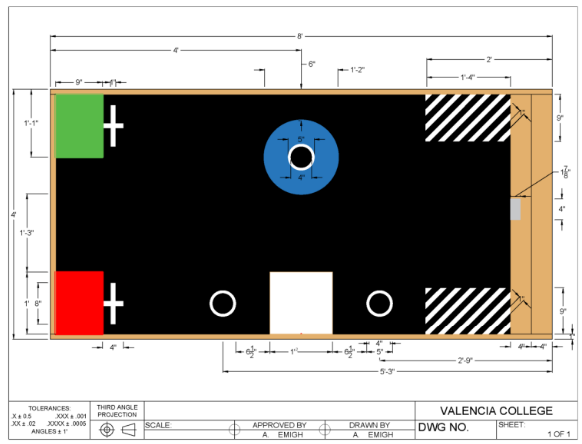


Figure 1. Playing Board [1]

There are 10 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 place the pink duck on top of the reassembled statue.

Figure 2. Duck Object [1]

The statues must be rebuilt by the robot. Seven pedestals support the statues; three of them are white, two are green, and two are red. Each statue's bottom pedestal is made up of three white statue bases. The second level for two of the sculptures is supported by the two green pedestals. The red statue pedestal is the third level of the statues that are three high.

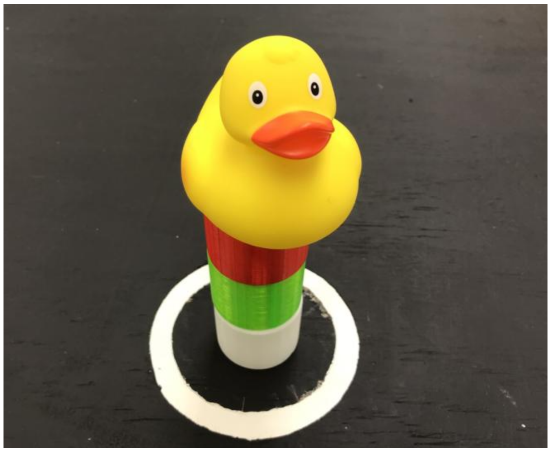


Figure 3. Statue with Duck on Top

Figure 4. Duck Pond

Another objective of the hardware competition is feeding the alligators and manatees in their designated aquariums housed in the corners on the left side of the park, each aquarium measuring 9” x 12”. Each team will be provided with three red and three green 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. 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, seven points for correct animal-chip feeding, and three points for incorrect animal-chip feeding.

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. This area is used to dispose of unused items (pedestals, food chips, ducks, etc.) from the field.

The last objective is the fireworks display. There will be a horizontal switch that is to be connected to a Raspberry Pi controller and a computer monitor. The switch, when flipped, will run the program on the Raspberry Pi to play a 5 second fireworks video. The code may be in Python or Java, but must run on the Raspberry Pi. The video file must be a 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.

C. “Shall” statements

Shall adhere to all IEEE SoutheastCon competition rules and regulations outlined in the Hardware Competition Rules.

Shall build a fully autonomous robot which will complete tasks deemed valuable in the planning process.

Shall design the final product considering safety, health, and welfare of the public and to strive to comply with ethical design and development practices [2].

Shall seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, to be honest and realistic in stating claims or estimates based on available data, and to properly credit the contributions of others [2].

Shall design an autonomous robot with a single start button and a single emergency stop button that is easily accessible in the case of an emergency.

Shall design an autonomous robot that will earn all possible points for feeding the alligators and manatees during 90% of the rounds in the competition.

Shall design an autonomous robot that will obtain greater than or equal to 50% of the points available for placing ducks in the pond during the competition.

Shall design an autonomous robot that will activate the fireworks display during each round of the competition.

Shall design an autonomous robot that will place at least one statue of three pedestals in an inner circle at least 60% of the rounds played and place two statues of three pedestals at least 30% of the rounds played.

Shall design an autonomous robot that will place at least one unused item in the recycling attraction at least 20% of the rounds played.

III. Solution Statement

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

The team will analyze value versus difficulty for each of the tasks and assign a numerical ranking to each task. This ranking is shown in Table 1, and the team unanimously agreed upon this ranking 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 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 will then start literature review on what has worked in the past for robot design. In this phase the team will gain valuable insight into the field of robots and the existing tools and libraries that are available for us to use in design. Each tool will be analyzed by a team member to find if each is tractable for use in the project. 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.

Table 1. Value versus Difficulty Analysis for Each Objective

	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

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/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 +/- 7 days.

IV. Obstacles

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.

The robotics competition rules are subjectively much more difficult this year than in recent years past. The rules embed large elements of randomness into the playing field, and that usually makes science and engineering problems more difficult to solve. To address this, we plan on using random trial runs and worst case scenarios during testing so that randomness is less likely to take us by surprise during the competition. We will need to use several trial runs and introduce probabilities when testing in order to accomplish the goal sufficiently.

The hardware competition rules outlined for this year explicitly state that the arena measurements are guaranteed to be within 15% of the published measurements in the specification. This means the arena model we test with and the arena model outlined in the hardware competition rules handout might vary related to the arena on competition day at SoutheastCon. This also means that, in the absolute worst case, the different arenas at the conference center on competition day could vary from one another within 30% tolerance of one another. The team will need to design mapping and localization smartly to be successful given the 15% tolerance random element in the specification.

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.

V. Benchmark Model

There are different types of Pick and Place Robots such as Cartesian Robots, Fast Pick Robots, Robotic Arms, Delta Robots, and Collaborative Robots [3]. The cartesian robots use X, Y, and Z coordinates to move objects in several planes [3]. The fast pick robots are used in high volume applications because they can pick objects extremely quickly; about 300 objects may be moved every hour by these robots [3]. The collaborative robots work in tandem with humans, their goal is to direct humans to the picking or desired area, these robots can devise an efficient path to reduce travel time [3]. Delta robots are capable of picking objects and arranging them in specified assembly patterns or groups, these robots can be outfitted with sensors or vision systems that allow them to select items based on their color or size [3]. Robotic arms are the most basic and widely used sort of pick and place robot, they are utilized as 5-axis and 6-axis robotic arms. The 6-axis robotic arm functions similarly to cartesian robots but has lesser positioning precision than delta robots [3].

Based on the project's requirements we can conclude that we might need a Pick and Place Robotic Arm, because it is the most basic and simple kind of pick and place robot. This research is based on Pick and Place Robotic Arm.

A. Pick and Place Robotic Arm:

Pick and place robots use sensors and vision systems, these robots come in a variety of designs depending on the precise task they are utilized for [3]. Most pick and place robot designs have a similar fundamental idea. These robots often have a long arm that can reach their whole working area and are mounted on a stable stand [3]. According to the kind of things the robot plans to move, the end of arm attachment is tailored. These robots can move objects from a moving surface to a moving surface, from a moving surface to a stationary surface, and from a stationary surface to a moving surface [3]. A 5-axis robotic arm is used in straightforward pick-and-place robots, which raise objects and position them in different places. However, 6-axis robotic arms are also in use, which can twist the objects to change their orientation [3]. Some elements will be the same across all designs which are joints, robot arm tool, base, grippers, manipulator, end effector, actuators, sensors and controller [4]. A pick and place arm is made up of two rigid components that are joined by joints. These joints facilitate simpler movement for these robotic arms [4]. The degree of movement freedom is determined by the joints. It is possible to employ rotational joints or linear joints [4]. A robotic arm is a robot's extension made of cylindrical or spherical components. The arm is assisted in making the required movements by a stiff body that supports it. Additionally, it has some grippers [4]. The body that supports and guides the arm is referred to as the manipulator. Since the joints are the only moving parts, they are extremely important [4]. Grippers are what are utilized to pick up objects and set them in the required destination. These grippers are available in various sizes and strengths [4]. Both the arm and the manipulator are supported by the base. This guarantees the pick and place arm's durability and effectiveness [5]. End effectors are the accessories at the end of robotic arms that perform certain tasks, including grasping items. Depending on the needs, the end effectors can be built to execute a variety of functions [5]. The robotic arm and end effectors are moved by actuators. Any sort of motor, including servo motors, stepper motors, and hydraulic cylinders, can function as a linear actuator [5]. The sensor serves as the robots' eyes and performs functions including determining an object's location [5]. Controllers are the main driver behind a robot's efficient functioning because they coordinate and regulate the motion of all of the robot's actuators. The arm's location, its motions, as well as the passage of time are all tracked by the controller [5].

A. DOF of Robotic Arm

DOF means Degrees of freedom. Each degree of freedom represents a joint on the arm, allowing it to bend, spin, or translate [6]. The number of actuators on the robot arm is often used to determine the number of degrees of freedom [6]. We need to design a robot arm with limited degrees of freedom because each degree requires a motor, sometimes an encoder, and exponentially sophisticated algorithms and costs. Because grippers are frequently complex with multiple degrees of freedom, they are treated separately in basic robot arm design [6]. A linkage of some length connects each DOF. A joint may have multiple degrees of freedom in the same location at times [6]. The configuration space is another limitation of the DOF. Some joints cannot swivel 360 degrees. A joint's maximum angle is limited [6]. Limitations could be caused by wire wrapping, actuator capabilities, servo maximum angle, and so on [6]. The robot arm can be mounted on a mobile base, which adds more degrees of freedom. A rotation joint exists if the wheeled robot can rotate; a translational joint exists if it can move forward [6].

B. Robot Kinematics

Forward kinematics is a method for determining the orientation and position of the end effector given the robot arm's joint angles and link lengths. We will use trig and algebra to calculate forward kinematics [6].

C. Motion Planning

End effector velocity on a straight arm = 2 * pi * radius * rpm [6]. The end effector may move in a variety of directions in addition to rotating around the base. The end effector can move in a straight line, a curve, or both. The fastest path between two places using robot arms is frequently not a straight line [6]. If two joints have separate motors or bear different loads, their maximum velocity might differ. When the end effector moves from one location to another, you have two options [6]: allow it to travel in a straight path between both sites, or instruct all joints to move as quickly as possible, allowing the end effector to swing wildly between them [6].

D. Arm Sagging

Arm sagging is a typical problem with poorly built robot arms. When an arm is overly lengthy and heavy, it bends when stretched externally. The team will make sure the arm is strengthened and lightweight while creating it [6]. Conduct a finite element analysis to calculate bending deflection/stress. When the arm wobbles back and forth in stop-start movements, the sagging issue is exacerbated [6]. Use a PID controller to develop a solution that will slow the arm down before coming to a complete halt [6].

E. Sensing

Without a list of preprogrammed places, a robot arm might move autonomously between points using simple visual feedback algorithms [6]. It could really reach for it if the arm was given a red ball. The end effector might be instructed to move to the same X-Y location if the arm can identify a spot in an image's X-Y space (by using inverse kinematics) [6].

Force feedback sensors and current sensors are frequently used in tactile sensing. These sensors identify collisions by identifying sudden force or current spikes that indicate a collision has taken place [6]. By monitoring force, a robot end effector can determine whether a grip is successful and when it is not. Utilizing current limiters is another approach since unexpectedly high current draws typically indicate a collision or contact [6]. Knowing whether an object is heavy or light and maybe even identifying the thing by its weight would allow an arm to modify end effector velocity [6].

VI. Evaluation Metrics

The team's evaluation metrics will be evaluated within three periods of time for the duration of the capstone class. Because the project is so involved, it is crucial to continually check for our success throughout the entire process. Each time period will have its own set of expectations the team agreed upon before design of the robot began. Throughout the design, the team should conduct many trial runs that very closely, if not exactly, replicate the conditions and time constraints of the competition in order to obtain an accurate representation of the true performance of the robot.

A. Pre-Competition

Before the competition, it should be determined how many (or what percentage) of the tasks the robot can complete within the time constraints. A metric to be used in determining how well the robot is completing the tasks would be determining the percentage of points earned out of total points possible for the task trying to be accomplished. Using the difficulty versus the point analysis, the team will decide which tasks the robot is to realistically complete in the competition before the design is implemented.

Performance will also be evaluated based on individual contribution to the team. Individual contribution can be measured throughout the semester by analyzing tasks completed by each team member and also each team member's attendance in weekly meetings.

Specifically, there are quantifiable metrics for each of the tasks before the competition. For manatee and alligator feeding, 90% of the previous 10 trials obtain 100% of the possible points. For the duck pond duck placement, our average in the last 10 trials had 50% of the ducks placed in the pond. For the fireworks display, our goal is to successfully flip the switch and play the video of the fireworks display for 80% of the previous 10 trials. For the statue placements, for the last 10 trials 30% of the time, two statues that are three pedestals high are built. In addition, 60% of the time, one statue that is three pedestals high will be built. For the recycling attraction, during the last 10 trials we hope to have gotten at least one item in recycling 20% of the time.

B. Competition

During the competition, the robot should be considered a success if it meets the expectations laid out before the competition began. These expectations will include: design focuses to exploit point versus difficulty analysis for each task, following the planned task completion ordering, ability to run the full round duration during the competition assuming that all tasks haven't been completed.

Specifically, there are quantifiable metrics for each of the tasks during the competition.

For manatee and alligator feeding, 100% of the possible points on each round.

For duck pond duck placement, have 50% of the ducks placed in the pond at game completion.

For the fireworks display, the goal is to flip the switch to activate the fireworks video during the competition for each round during the competition.

For the statue placements, at least one statue of three pedestals is placed in the inner circle for 60% of the rounds played and two statues of three pedestals are placed in the inner circle 30% of the time.

For the recycling portion, at least one item placed in the recycling area 20% of the rounds.

C. *Post-Competition*

After the competition is complete, the project will be considered successful if the presentation and visuals adequately depicts professionalism, competency, and proficient knowledge of the topics demonstrated within the design. This will be measured by asking for feedback from the audience.

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 delve into technical design for each subsystem. The team will constantly be refining the process as the team members get deeper into technical problem solving.

The overall design for this robot will need to be designed with robustness in mind. The hardware competition specification randomness outlined in the "Obstacles" section of this handout will require the team to design a highly reliable system which is not prone to faults if the exact arena design specifications are not met closely. This means that very few assumptions can be made, and the worst case will likely have to be considered for designs to be successful at the competition.

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 reconsider and begin recruiting 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. In dealing with artificial intelligence, it is always important to stay mindful of when to use and not to use artificial intelligence, and the ethical concerns involved in how it is developed (bias, safety, etc.). The fact that it is an intelligent, autonomous robot could pose some issues with safety if it were to malfunction. 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. This can be avoided by designing with the environment in mind. All batteries and other materials in the robot will need to be disposed of properly in order to ensure that waste from this project will not harm the environment.

Finally, societal, environmental, and economic impacts of the project will be optimized to reflect the IEEE Code of Ethics [2].

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 power in order for it to be fully autonomous and functional. It will also need to be a level of power that will not overload the robot or interfere with its other functions during operation.

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 can be turned off 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. 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. Citations

[1] “IEEE SoutheastCon 2023 hardware competition,” *IEEE SoutheastCon 2023 Hardware Competition*. [Online]. Available: https://ieeesoutheastcon.org/wp-content/uploads/sites/392/IEEE-SoutheastCon-2023-Hardware-Competition-Rules-v1.4.pdf. [Accessed: 12-Sep-2022].

[2] “IEEE code of Ethics,” *IEEE*, 1912. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 13-Sep-2022].

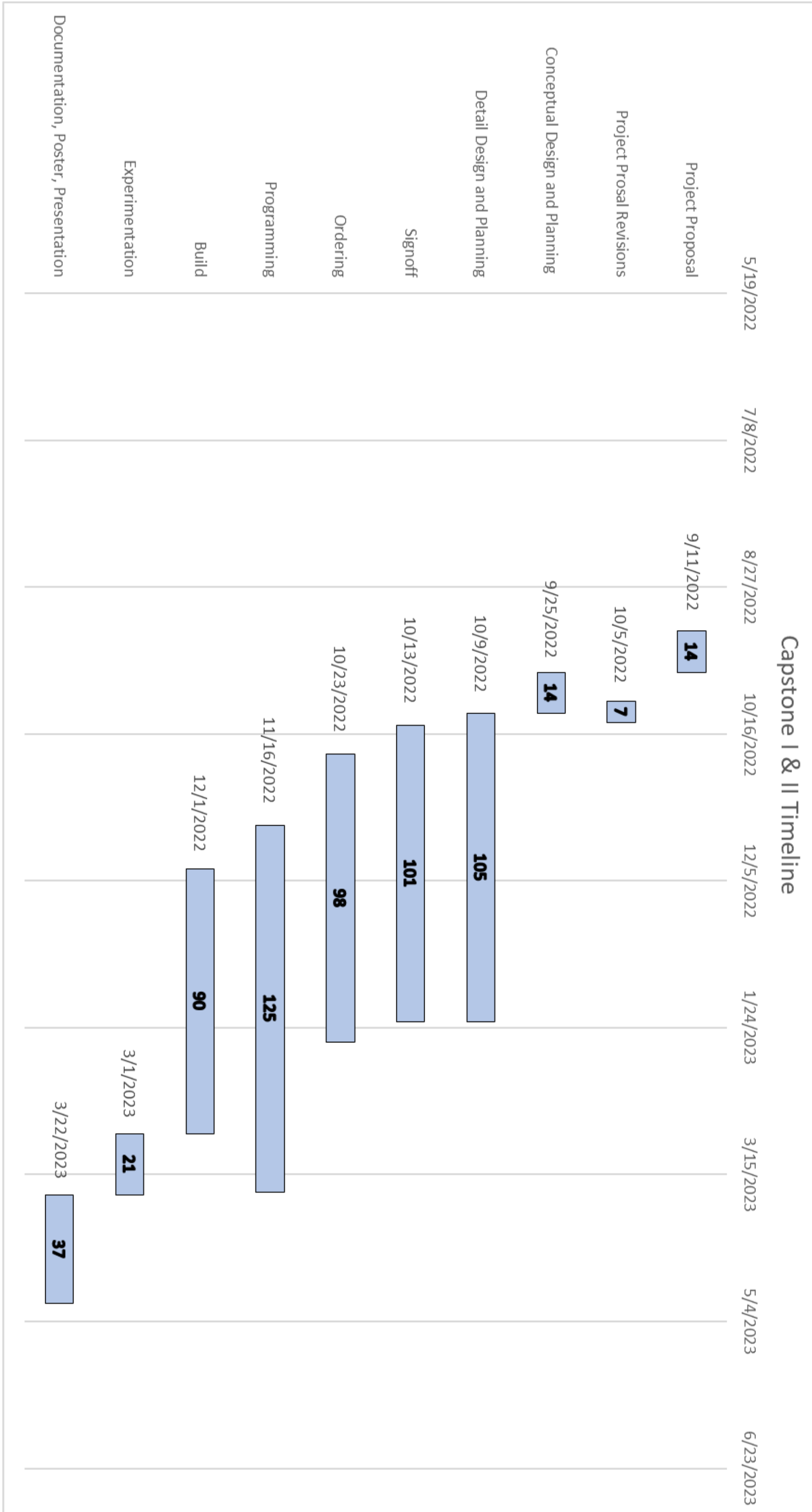
[3] “What are Cartesian Robots? - Technical Articles,” *control.com*. https://control.com/technical-articles/what-are-cartesian-robots/

[4] “Pick and Place Robot Arms: Everything you Should Know - EVS Robot,” *www.evsint.com*. https://www.evsint.com/everything-you-should-know-about-pick-and-place-robot-arms/

[5] A. Lightstead, “What is a Pick and Place Robot and How Does it Work?,” *PWR Pack*, Feb. 22, 2022. https://www.pwrpack.com/what-is-a-pick-and-place-robot/ (accessed Sep. 23, 2022).

[6] “How to Build a Robot Tutorials - Society of Robots,” *www.societyofrobots.com*. https://www.societyofrobots.com/robot_arm_tutorial.shtml#DOF (accessed Sep. 23, 2022).

Table 2: 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

Figure 5:Scoring for Southeast Con Competition [1]