4 Design

4.1 Design Content

Hacking/Cybersecurity Traps: These traps would likely involve electronic components such as sensors. Microcontrollers, and modification of communication systems. The design content for these traps would include:

- Sensor Jamming Zones: This involves creating zones on the track that would jam or disrupt the electronic sensors on the RC cars, leading to a temporary loss of sensor data. The design includes a selection of sensors, jamming mechanism, and strategies to execute sensor jamming scenarios.
- Light/Shadow Challenges: These challenges would introduce scenarios on the track where light and shadows will be manipulated, possibly causing interference of the control to the RC car. Depending on what type of sensors the RC car uses, the RC car may react differently to the different lighting scenarios. The design content covers the implementation of light and shadow sensors, control algorithms that respond to the varying light conditions, and a track design that could maximize the effect of these challenges.
- Control Takeover: This would involve creating situations where we can temporarily take over control of the RC cars. Design content for this challenge would include incorporating communication systems (radio signals) and protocols that allow us to take over RC car operations.

Electronically Complex Traps: These traps would introduce physically moving elements on the track that are controlled electronically. The design content for these traps would include:

- Mechanical Design: development of the physical components of the moving parts, such as rotating barriers, elevating platforms, or sliding obstacles. This would require the use and knowledge of CAD design as well as electrical engineering principals
- Electronic Control Systems: Integration of sensors and microcontrollers to that would be used to control the behavior of the moving parts. This involves designing control algorithms that would respond to the RC car's presence or other specific triggers.
- Power Management: Designing power systems that ensure the moving parts receive the necessary electrical supply. This would include battery management or wired connections for each of the components.

Physical Traps: This aspect of the project would involve the creation of physical obstacles or traps on the track that would challenge the RC car teams. The design content would include:

- Terrain Design: Design the track layout and surface materials, which may include sand, gravel, or other obstacles like ramps.
- Safety Measures: As per the requirements of the car teams, we will need to make sure that none of these physical traps flip the car over in any way. We will also need to make sure that these traps are designed with safety in mind to prevent damage to the RC cars or harm to any of the participants.
- Environmental Safety: We will consider factors like weather resistance as the final track will take place outdoors.

4.2 Design Complexity

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles
2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

The building of the track requires an understanding of constriction with wood. As part of the track, we need to add traps and a way to time the racers. The traps will require an understanding of multiple engineering disciplines and technologies. The traps will require programming, wiring, mechanical design, and an understanding of Arduino.

4.3 Modern Engineering Tools

Arduino is our control of the traps and for timing the racecars. To program Arduino, we will use the IDE that Arduino provides and store the code on GitHub provided by I.S.U for ease of retrieval.

AutoCAD electrical to make the 2D model of the circuitry of the traps.

Breadboards will be used to make and test the electrical circuits for the traps.

We will be using AutoCAD, or something similar, the design of the tracks and physical parts of the traps.

4.4 Design Context

Area	**Description**	
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)	When it comes to enhancing our well-being, racing RC cars involve various skills, such as hand-eye coordination, problem-solving, and technical knowledge. These skills can have educational and developmental

		benefits for participants, particularly for younger individuals.
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	The racetrack can serve as a hub for the local community, bringing people together for shared interests and activities. It can become a central meeting point that strengthens community bonds. In addition to providing communities with a gathering place, racetracks also provide a fun and educational activity like RC car racing and engage young people in a positive hobby, keeping them active and connected to their peers.
Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.	Electric-powered RC cars are cleaner and quieter than their gas-powered counterparts. Encouraging or mandating the use of electric RC cars can help reduce air and noise pollution in the surrounding area.
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	The construction and operation of the RC car racetrack can create job opportunities, from track staff and maintenance personnel to event coordinators and marketing professionals

4.5 Prior Work/Solutions

This open-ended project has never been attempted before. A similar project that we found is something called the micromouse competition. To be brief, this project involves motorized robots the size of mice navigating a maze. Designs involving navigation could be similar as cars for our track will have to navigate to stay on the track and to avoid obstacles similar to these micromouse bots navigating through a maze. As previously mentioned, this is the first iteration of this project and will be completely original with no previous work to reference.

Our project has the possibility to use market products such as RC cars. However, modifications to make the cars semi-autonomous will drastically change their performance. The track will be built from

scratch to accommodate modifications on the RC cars so that they are compatible. A list of pros and cons compared to other similar designs is provided below.

Pros	Cons
• Semi-autonomous • Track tailored towards cars • Adjustable traps and car configurations	• Not fully controlled movements • Small budget could limit design and prototypes

4.6 Design Decisions

Software-

- Control Software for Traps
- Cybersecurity Framework
- Simulation and Testing Software
- Microcontroller Platform Selection (Arduino IDE)

Hardware-

- Sensor Selection
- Microcontroller and Communicaton Hardware Selection
- Safety Systems (Power Supply for Motors)
- Physical Trap Layout on Track
- Track Construction Materials

4.7 Proposed Design

At this point in the project, we have worked with the other two teams to set regulations on various specifications such as rules for the track (the track shouldn't damage the cars), the size of the cars, and various regulations regarding how the cars can be hacked. We have also determined the general shape of

the track, designed some of the traps, and have created two different track designs for indoor and outdoor use.

4.7.1 Design 0 (Initial Design)

Design Visual and Description

The visuals below show two variations of our track design. The first is for if the race is done outdoors in the parking lot of Applied Sciences Complex (lot 104) and the second is for if the race is done indoors in the TLA at Coover Hall. Both of the two designs implement the same traps. In the current design, there are four physical traps that the cars will have to evade as well as four hacking traps where the cybersecurity of the cars will be tested. The current physical traps are a ramp, a moving wall, a faraday cage, and a strobe light.

Strobe light- visibility during races, especially in low-light conditions

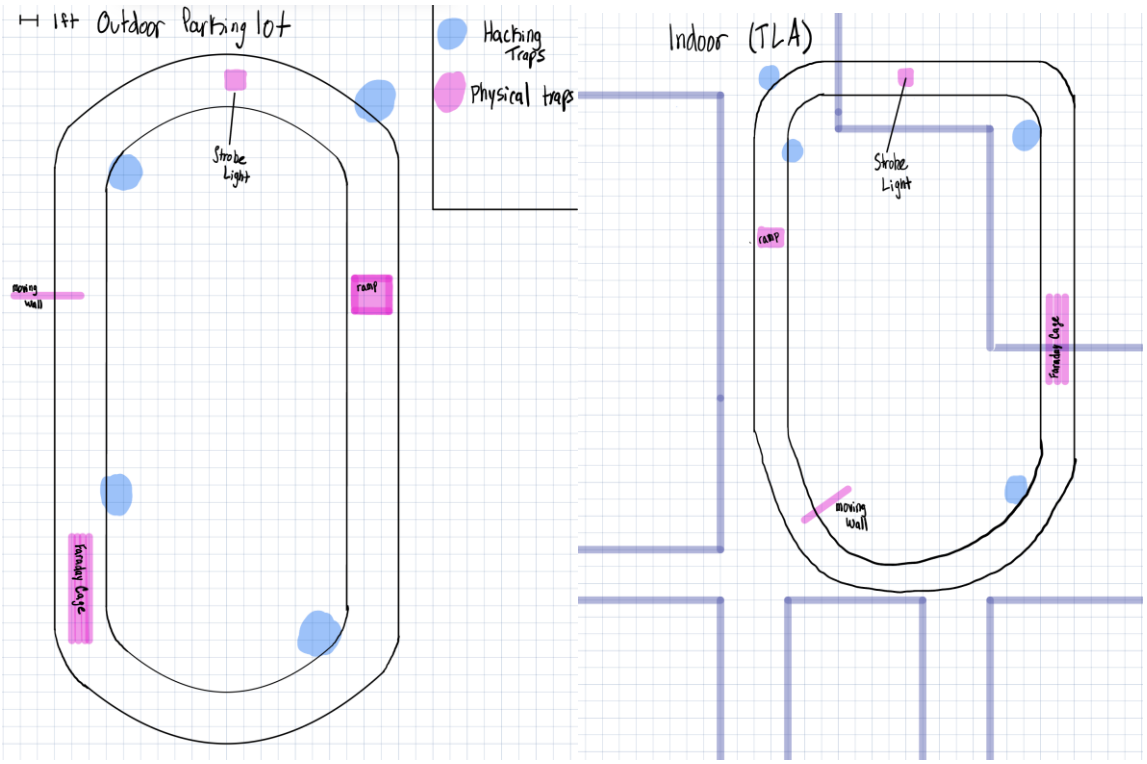
Moving walls Ramp- The purpose of this obstacle is to hinder the race car but

Faraday cage- to be able to have a station to hack the car within the track.

Functionality

The cars will start at a designated starting line, and the amount of time it takes them to complete the track will be recorded. Whichever car has the fastest time will be the winner.

Each of the traps depicted below is reusable and should not cause physical damage to the cars. None of these traps should eliminate the ability to finish the race.



4.7.2 Design 1 (Design Iteration)

Include Include another most matured design iteration details. Describe what led to this iteration and what are the major changes that were needed in Design 0.

Design Visual and Description

Include a visual depiction of this design as well highlighting changes from Design 0. Describe these changes in detail. Justify them with respect to requirements.

NOTE: The following sections will be included in your final design document but do not need to be completed for the current assignment. They are included for your reference. If you have ideas for these sections, they can also be discussed with your TA and/or faculty adviser.

4.8 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

4.9 Design Analysis

- Did your proposed design from 4.7 work? Why or why not?
- What are your observations, thoughts, and ideas to modify or iterate further over the design?