RACE OF DOOM

DESIGN DOCUMENT

Team #44

Client – Timothy Bigelow (bigelow@iastate.edu)

Advisers – Timothy Bigelow (bigelow@iastate.edu)

Team Members/Roles -- Zechariah Mundy, Vincent Quattrone, Simon Aguilar, Taylor Moore, Chris Agyare, Jaxon Dennis

Team Email – sdmay24-44@iastate.edu

Team Website – https://sdmay24-44.sd.ece.iastate.edu

INTRODUCTION

In an era where technology is continually reshaping the landscape of entertainment and competition, our integration of advanced engineering techniques with recreational activities will open new avenues for innovation and excitement. Our Project, The Race of Doom, involves the development of an RC racing track with dynamic and interactive traps. We believe our design stands at the intersection of technology and sport and will enhance the racing experience by adding layers of strategic challenge and technical complexity.

PROBLEM STATEMENT

The core challenge that our project addresses is the static nature of traditional RC racing tracks, which often fail to test the adaptability and ingenuity of participants. Our objective is to infuse the race with elements that not only test speed, but also strategic maneuvering and technological resilience through the use of sophisticated traps

The project aims to enhance the excitement and challenge of RC racing by introducing innovative traps on the track. It provides an engaging and dynamic environment for RC enthusiasts, offering a unique and entertaining experience.

INTENDED USERS AND USES

This racetrack is intended to be used by the local RC enthusiasts and the broader community who are looking for more of a challenge by modifying their cars. Our goal is to serve as a hub for social and educational engagements by incorporating elements of both physical and cybersecurity challenges. Our track is designed to provide a multifaceted experience that appeals to hobbyists, students, and technology aficionados alike, fostering a space of competition, learning and community building.

In addition to its entertainment value, our track offers significant educational benefits by exposing users to complex problem-solving scenarios that involve real-time programming and mechanical adjustments. The combination of physical traps and cybersecurity elements adds a multidimensional aspect to the RC track. It not only tests the participants' skills in creating autonomous cars, but also introduces elements of strategy and adaptability, making it a compelling project for educational purposes or recreational events. The integration of electronic components and cybersecurity features may require technical expertise, making it ideal for a senior design project or an advanced class with appropriate resources and support. With proper guidance and resources, the implementation of such a project can offer valuable hands-on experience in electronics, cybersecurity, and creative design. Given the size of the track, we also believe that it can serve as a central hub for events that bring together people with shared interests in technology, engineering, and racing.

CONTEXT OF RELATED PRODUCTS AND LITERATURE

Unlike traditional RC tracks that focus solely on navigation and speed, our design integrates advanced traps that involve cybersecurity challenges such as wireless security and electronically complex obstacles, such as moving walls. This approach not only helps differentiate our track by elevating the technical stakes, but also by enhancing the interactive experience, making it unique in its ability to engage participants on multiples levels.

REVISED DESIGN

REQUIREMENTS (FUNCTIONAL AND NON-FUNCTIONAL)

As we create a racetrack for two RC cars, there are many factors that must be considered. The materials used to physically create the track must be durable enough to allow for multiple rounds of testing, as well as multiple attempts for each car team to perform the race. The largest consideration for this project is likely the creation and implementation of the traps. Each trap, be it software or hardware based, must be tested to ensure that it will slow the cars as they progress through the race while still allowing them to complete it. Special attention is given to the traps' compliance with legal standards, ensuring that RF signals employed for hacking or jamming purposes are weak enough not to cause disturbances. Furthermore, the integration of a timing system is vital for determining race winners, and the applied science complex parking lot 104 provides an ideal real-world testing environment for the track. The final consideration lies in collaboration with the teams in charge of creating the cars.

ENGINEERING STANDARDS

IEEE 829	Software Test Documentation
IEEE 1028	Standard for Software Reviews and Audits
IEEE 1074	Software Development Life Cycle
IEEE 1547	Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
IEEE 2050	RTOS for embedded systems standard
IEEE C37.2040	Standard Cybersecurity Requirements for Substation Automation, Protection, and Control Systems
IEEE 260	Standard Letter Symbols for Units of Measurement

SECURITY CONCERNS AND COUNTERMEASURES

Our design presents several security concerns that needed to be addressed to ensure safety. Key issues include wireless safety interference, which could impact nearby electronic devices, and the risk of unauthorized access or tampering with the racetracks technology-driven features like the moving walls and timing systems. Physical safety for the participants and spectators was also paramount, especially given the ramp that could cause cars to fall off the track.

To address these security concerns within our design, we implemented a range of countermeasures to ensure comprehensive safety and integrity. For wireless safety interference, we've contained the frequency shielding by keeping the faraday mesh and the tinfoil within a closed box environment. To protect against unauthorized access and tampering, we made sure to check with Howe Hall to ensure that our track and the traps within the track can be protected and safely stored overnight. Lastly, we ensured that everyone was safe during race day by asking the autonomous car to turn down their speed slightly, and to be sure to protect themselves and others while cars are attempting the ramp trap.

DESCRIPTION OF HOW YOUR DESIGN HAS EVOLVED SINCE 491

When beginning this semester, we had a complete design created, and ready to be implemented. We progressed through, however, we realized the cybersecurity traps would have to be removed to stay within budget and remove the possibility of legal trouble. After doing some electronic modeling of the track diminutions we found that the track's overall dimensions need to change the total width of the track need to be changed from 11 feet to 9 feet. We also need to reevaluate the lap timer because of the Sensor chosen which could only be used for a 20-inch opening and the track width is 3 feet.

The faraday cage implementations had a few modifications as well. At first we were going to just have the fabric so we can try and block high and low frequencies, however the fabric would just block the low frequencies, so we wrapped the fabric with aluminum foil to cover the high frequencies.

Lastly, we had the moving walls and beforehand the idea was to use wooden walls and wheels to connect to the motor. The problem was that we had an abundance of weight on the motor to move it. So what we acquired was cardboard to compensate for the weight on the motor. Doing this, we wouldn't have to worry about the motor messing up the torque of it.

IMPLEMENTATION DETAILS

Traps: To implement the traps effectively, we first finalized the designs for each trap based on testing. For the Faraday cage, we made sure the shielding material blocks external signals by completing thorough testing with various signal sources. The moving walls have been constructed using lightweight materials such as cardboard to optimize wall movement speed while staying within budget. Servo motors will be calibrated to move the walls smoothly and consistently, with adjustments made to maximize performance within the constraints of the motors' capabilities.

Track: The track involved assembling recycled materials such as cardboard to form the track layout. Each section of the track will be securely connected to withstand repeated use and testing. Our team has made sure to focus attention on creating a smooth surface to minimize friction and ensure consistent performance of the RC cars. The track layout will accommodate trap placement at strategic points to challenge participants while maintaining the race flow.

Terrain: Terrain elements such as ramps and uneven surfaces have been added into the track design to add variety and challenge. Ramps can and will be adjusted to find the optimal angle for the various RC cars, balancing difficulty with feasibility. Surface textures will be chosen to provide traction without negatively impacting the movement of the cars.

Detailed Design

For our design, the use of walls, white tape, asphalt flooring, and traps were carefully thought out to optimize both the challenge and functionality of the racetrack. The walls, constructed from cardboard, were used to define the course boundaries and serve as a physical barrier that would help guide the cars while adding some structural integrity to the track layout. These walls were specifically utilized by one car team as their main boundary to navigate the course. Conversely, for the other car team, we used white tape strategically placed along the inside of the track edges. This tape provided a stark contrast to the dark asphalt flooring, enhancing the visibility and assisting the navigation of their automated vehicle.

The choice of asphalt for the flooring was pivotal. Its slightly rough texture offered an essential grip on their tires that aids in the stability and handling of the RC cars. This grip was crucial for maintaining control while on the track, particularly when navigating through the strategically placed traps. These traps, which included obstacles like moving walls, a ramp, and a faraday cage, were all designed to test the car team's skills and the cars' capabilities. They introduced a sort of unpredictability and excitement to the racing experience, requiring strategic thinking from the participants.

Together, these elements – walls, white tape, asphalt flooring, and dynamic traps – create a multifaceted racing environment that was not only challenging but also engaging. This design approach ensured that our racetrack stands out by offering a unique blend of technical difficulty and entertainment, catering to both novice and experienced racers looking for an innovative RC racing experience.

Description of Functionality

The functionality of our design was to provide an entertaining and challenging project that integrates advanced engineering and imaginative design to create a dynamic and engaging experience for both participants and spectators.

Traps such as the Faraday cage and the moving walls, made from lightweight materials and controlled by servo motors, add complexity and unpredictability to the races, testing racers' adaptability and strategic thinking. The track, constructed from sustainable recycled cardboard, features a smooth surface wall to stop cars from exiting the track and improve overall car performance and times. The track also includes strategically placed traps and adjustable terrain elements like ramps and uneven surfaces, enhancing the challenge while maintaining race flow. The asphalt flooring provides essential tire grip, crucial for optimal car control, when navigating through traps. This design effectively combines innovation and sustainability, ensuring exciting and durable racing conditions.

Notes on Implementation

Because of our commitment to sustainability and our environment, the track materials were chosen from recycled materials like scrap wood, and cardboard.

TESTING

PROCESS

Multiple portions of this project were tested individually followed by testing their integration in their final function. The function of the faraday cage, ramp, moving walls, timer, and the floor and walls of the track each went through compatibility testing with both cars from the other teams. Adjustments were made to traps to compromise on its interaction and functionality with respect to both car teams. Many changes or additions in our design were implemented because of the continuous testing throughout the process.

RESULTS

For our faraday cage, some signals were still penetrating our shell. To remedy this, we added a layer of tinfoil to block more signals from traversing inside the cage. This has been our best attempt at creating a trap that will block the signals to the car teams. However, the car teams have not had too much trouble traversing through this trap. For the ramp, our angle of ascent was very steep and very difficult for the car teams to traverse accurately. We shortened the height of ramp making the angle much shallower allowing the teams to traverse this obstacle. For our moving walls, a lot of the changes were due to limitations in our instruments. The servo motors we acquired were very small and not the most powerful. This led to them struggling to move our plastic material the walls were made of. We replaced these with Styrofoam and eventually cardboard to maximize speed and accuracy of the walls.

BROADER CONTEXT

ECONOMIC

The introduction of our RC track should significantly boost local tourism and the economy. As a unique attraction, it will draw a diverse crowd, increasing spending and benefiting local businesses like hotels, restaurants, and shops. This influx of visitors can lead to broader economic developments, including new infrastructure investments and enhanced public services. Additionally, the racetrack may foster collaborations with local education institutions and tech firms, creating educational and sponsorship opportunities. Overall, the racetrack boosts immediate tourism revenue and catalyzes broader economic and community development, enhancing the region’s profile as a center for innovation and leisure.

ENVIRONMENTAL

The environmental impact of our RC track, particularly in terms of noise pollution, is a crucial consideration, especially given its role as both a tourist attraction and a spectator event. The noise from the high-speed RC cars and attending crowds could violate local noise ordinances and disturb nearby residents, especially if the track is close to resident areas or operates during late hours. Implementing sound-dampening technologies, adjusting event timing, and conducting regular noise assessments are essential to mitigate these issues. These steps will ensure compliance with environmental standards and maintain community harmony, enhancing the project's local acceptance.

Global, Cultural, and Social

Our project exemplifies significant global, cultural, and social impacts through innovative integration of technology diffusion, influencing education strategies worldwide, and setting new standards for integrating recreation technologies with education and competitive elements. Culturally, it shifts perceptions of traditional pastimes by infusing them with modern technology, promoting inclusivity, and fostering community identities centered around technology and sports. Socially, the project enhances community engagement by providing a platform for social interaction and intellectual stimulation. It offers substantial education opportunities, particularly in STEM fields, helping to bridge educational divides by equipping participants with essential skills in problem-solving, teamwork, and technical proficiency. These contributions collectively underscore our project's roles in driving technological integration, educational innovation, and community development on a broad scale.

Public Health, Safety, and welfare

Our project positively impacts public health by promoting physical activity and reducing social isolation, enhancing community mental health through social engagement. Safety is critical, requiring robust measures like secure walls and strict rules to protect participants and spectators. Our project also boosts local welfare by providing a new recreational facility and stimulating economic activity, enhancing the community’s quality of life.

Conclusions

Review progress

Our project’s core challenge was to create an environment that tests not only speed but also strategic maneuvering and technological resilience. This was effectively addressed through the introduction of sophisticated traps such as moving walls, ramps, and a faraday cage, adding layers of complexity and interactivity that enhance the user experience. The design's evolution has been significant, moving from initial concepts to a more refined, practical implementation that balances entertainment, challenge, and educational value.

DISCUSS VALUE YOUR DESIGN PROVIDES TOWARD THE PROBLEM AND FOR USERS

The design of this dynamic RC racing track provides significant value on multiple fronts, primarily by transforming the traditional RC racing paradigm into an innovative, iterative, and educational experience. Our design addresses the problem statement effectively and capitalizes on the diverse interests and skills of the intended user base, offering a wealth of benefits ranging from entertainment to education development.

Our dynamic racing track revolutionizes traditional racing by integrating sophisticated traps and challenges that enhance engagement and replayability. This innovative design transforms each race into a unique, unpredictable event that boosts entertainment and tests strategic thinking. Beyond enjoyment, the track serves as a powerful tool, particularly beneficial for students in advanced technical fields like electronics, cybersecurity, and mechanical engineering. It provides hands-on learning experiences that apply theoretical knowledge in real-time, making learning more engaging and practical.

Furthermore, our track can foster community building by serving as a hub for local RC enthusiasts and technology aficionados, enhancing social interactions and networking opportunities among diverse groups. Our track encourages participants to continually innovate and improve their technical skills by modifying their RC cars to meet new challenges, keeping pace with technological advances. Additionally, our track is designed for sustainability and adaptability, making it capable of evolving with technological progress to maintain its relevance and appeal, ensuring long-term engagement and continuous learning.

POTENTIAL FUTURE STEPS

Looking ahead, we believe that if this project were to expand, the track would have plenty of opportunities to allow greater customization and track size or shape, ensuring that our track evolves with technological advances, and user feedback. One of the initial goals of this project was for it to be replicable and to be used by future classes in their senior design projects. As the scope of the project has changed drastically since it began, our failures and successes this past year can help to alleviate much of the initial unknown that we faced at the beginning of this process. For example, we faced significant difficulties in securing a location to hold the final race at the end of the year but now that we know it is possible and quite simple to reserve the atrium of Howe Hall, this should save future groups a lot of time and stress. Our struggles this past year can also help future students in standardizing the size of the cars to be raced, and a few of the traps should be adjusted to work better with the size of the cars. As this years cars vary so much in size, it became quite difficult to design the traps accordingly. In addition to this, future groups building and designing the track should only have electrical engineers, while the teams building and designing the cars should have both computer and electrical engineers, but there truly isn't much work that can be done by software engineers or cybersecurity engineers. In future years, it would be great to see this race become a larger scale community event so that it can be enjoyed by more people.

APPENDICES

APPENDIX 1 – OPERATION MANUAL

THE TIMER:

SET UP:

1) PLACE THE ULTRASONIC DISTANCE SENSOR FACING THE OPPOSITE WALL, THEN TAPE IT DOWN TO THE FLOOR USING THE TABS ON THE SIDE OF THE SENSOR MOUNT.
2) PLUG THE ARDUINO INTO A 5V DC POWER SUPPLY.

USING:

1) VEHICLE STARTS BEHIND THE ULTRASONIC DISTANCE SENSOR AND WHEN IT CROSSES THE SENSOR THRESHOLD THE TIMER WILL START. THE TIMER CANNOT STOP BEFORE A MINUTE HAS PASSED; THIS IS SO THAT THE CAR'S WHEELS DO NOT MESS WITH THE TIMING.
2) WHEN THE VEHICLE PASSES THE THRESHOLD AGAIN THE TIMER WILL STOP.
3) RECORD THE TIME ON THE DISPLAY.
4) PRESS THE ARDUINO RESET BUTTON.
5) YOU ARE READY FOR THE NEXT LAP.

TESTING:

1) START THE TIMER AND START A SECOND TIMER THAT YOU KNOW IS RELIABLE.
2) WAIT AT LEAST A MINUTE.
3) STOP BOTH TIMERS.
4) TAKE THE VALUE FROM BOTH TIMERS AND COMPARE THEM. IF THEY ARE EQUAL, THEN YOU ARE ALL GOOD.
    a. TO CORRECTLY COMPARE THE TWO, YOU WILL NEED TO TURN THE VALUE FROM YOUR RELIABLE TIMER INTO MILLISECONDS.

MOVING WALLS:

SET UP:

1. TO SET UP THE MOVING WALL TRAP, FIRST DESIGNATE AN AREA WITHIN THE TRACK LIMITS TO PLACE THE TRAP
2. ONCE A SUITABLE PLACEMENT HAS BEEN FOUND, PROCEED BY MAKING A GAP WITHIN THE WALLS THAT HAS ENOUGH SPACE FOR THE WOODEN SUPPORTS OF THE WALL TO LAY FLAT.

3. AFTER A HOLE HAS BEEN CUT WITHIN THE OUTER WALL OF THE TRACK, PLACE THE WOODEN SUPPORTS OF THE MOVING WALL WITH THE HINGE OF EACH MOVING WALL FACING YOU. THIS SHOULD CREATE A SOLID WALL ACROSS THE TRACK
4. NEXT, LAY THE WIRE CONNECTING BOTH WALLS TOGETHER DOWN JUST BEFORE THE WOODEN SUPPORT, THIS WIRE SHOULD ALSO GO ACROSS THE TRACK
5. TO DISTURB THE CARS AS LITTLE AS POSSIBLE, TAPE THE WIRE DOWN USING BLACK DUCT TAPE. THIS ALLOWS THE CARS TO DRIVE OVER THE WIRE SMOOTHLY AND DOES NOT GIVE ERRORS FOR WALL DETECTION.
6. ONCE THE WIRE IS PLACE ACROSS THE TRACK, PLUG THE PRE-FLASHED ARDUINO INTO THE POWER BANK

TESTING:

1. TO TEST THE MOVING WALLS PROPERLY, A CAR TEAM OR TEST CAR WILL BE NEEDED.
2. WITH A CAR, DRIVE UP TO THE WALL WHILE THE SERVOS ARE IN THE CLOSED POSITION, CAUSING A BLOCKADE OF THE TRACK
3. WHEN THE WALLS OPEN, MAKE SURE THAT THE CAR HAS ENOUGH TIME TO DRIVE THROUGH BEFORE THE WALLS BEGIN TO CLOSE AGAIN.
4. IF THERE IS NOT ENOUGH TIME, CHANGE THE FINAL DELAY NUMBER TO A LARGER NUMBER AND REFLASH THE ARDUINO

FARADAY CAGE:

SET UP:

1. PLACE FARADAY CAGE ON TRACK
2. ALIGN FARADAY CAGE WITH TRACK
3. LAY FARADAY FABRIC OVER CAGE. ONE OVER TINFOIL MESH AND THE OTHER TWO FROM LEFT TO RIGHT WITH RESPECT TO THE TRACK
4. DOUBLE CHECK ALL SIDES OF CAGE ARE COVERED

RAMP:

SET UP:

1. PLACE RAMP ON TRACK
2. PLACE 3X3 PLANK ON THE SIDE WITH 3 SUPPORTS. THIS SHOULD BE THE ENTRANCE FOR THE CARS TO GET ON THE RAMP
3. PLACE 3X1 BOARD ON THE SIDE WITH ONE SUPPORT. THIS SHOULD BE THE EXIT.
4. SCREW 3X1 BOARD INTO SUPPORT USING A WOOD SCREW.
5. ENSURE GAPS BETWEEN RAMP PIECES ARE NEGLIGIBLE

APPENDIX 2 – ALTERNATIVE/INITIAL DESIGN

VERSIONS CONSIDERED BEFORE LEARNING MORE ABOUT THE PROJECT

We initially faced challenges with the design and materials used in constructing a racetrack for RC cars. The first major issue was with the moving walls, which were initially made of wood. The wooden walls, being heavy, affected the performance of the motors that were supposed to move them, leading to inefficient interaction between the walls and the motors. Realizing this, we opted to switch from wood to Styrofoam, a much lighter material. This change significantly improved the functionality of the moving walls and the overall dynamics of the track, as Styrofoam allowed the motors to operate more efficiently and reliably. Additionally, the design of the ramp posed a challenge. Initially, the ramp's steepness was too great, making it difficult for the RC cars to ascend. This design flaw could potentially limit the enjoyment and functionality of the racetrack. We adjusted the incline of the ramp, making it less steep. This modification ensured that the ramp became manageable for the cars, striking a balance between challenge and playability. Lastly, the project highlighted the critical role of sensors in RC cars and the need to accommodate these sensors in the track design. Each car had different sensor requirements; car 1 was equipped with a Light R sensor, and car 2 had both ping and IR sensors. To ensure these sensors functioned correctly and did not misguide the cars, leading to unintended detours, we adapted the track's physical barriers. For car 1, we've used tape for the walls, which likely provided a clear path for the Light R sensor. For car 2, cardboard was used, which was chosen for its minimal interference with ping and IR sensors.

WHY THEY WERE SCRAPPED/REVISED

In the planning phase of our RC car racetrack project, we considered a variety of creative ideas to enhance the experience and functionality of the track. One of the initial concepts was to modify or 'hack' the RC cars themselves to improve their performance or add new features potentially. However, this idea was quickly found to be impractical due to legal restrictions. Modifying the electronics or software of commercially available RC cars could violate manufacturer warranties or regulatory compliances, which could lead to major legal repercussions. Another innovative idea was to introduce varied terrains on the racetrack, such as hills, dips, and different surface textures, to increase the challenge and simulate a more realistic driving environment. However, this concept also presented significant challenges. The varied terrains could disrupt the functionality of the sensors on the RC cars. These sensors, which might include ultrasonic, infrared, or light sensors, are critical for navigation and obstacle detection. Introducing complex terrains could confuse these sensors, potentially causing the cars to misdirect or fail to complete the race. This would defeat the purpose of having a fun and competitive racetrack.

APPENDIX 3 – OTHER CONSIDERATIONS

WHAT WE LEARNED

A lot of new skills have been learned through this project. Project planning and project management are two of the biggest skills we have learned. Project planning is the foundation upon which successful endeavors are built. It involves meticulously outlining the scope, objectives, timelines, and resources necessary to accomplish a specific goal. This process not only identifies potential risks and challenges but also provides a roadmap for navigating them effectively. By breaking down complex tasks into manageable components and establishing clear milestones, project planning lays the groundwork for efficient execution and ultimately, the achievement of desired outcomes. Project management is equally as important as it is the execution of the project plan. Managing a project is a large and complex task that requires tons of organization and communication. Another important skill we learned was woodworking and basic workshop etiquette. As many of us are electrical engineers, we didn't have as much experience physically building something of this scale. We ran into problems with structural integrity on our first couple of prototypes. We slowly learned more about the tools we were using and were able to implement newer designs to our prototypes to make them much more structurally sound.

APPENDIX 4 – CODE

TIMER CODE:

```
#include <HCSR04.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x3F, 16, 2);  // I2C address 0x27, 16 column and 2 rows

const int ledPin = 13;  // the number of the LED pin

long timeStart = 0;
long CurrentTimePased = 0;
double CurrentDistance = 0.0;
// variables will change:
int buttonState = 0;        // variable for reading the pushbutton status
int buttonPreState = 0;     // variable for keeping the pushbutton last status
bool Start_Timer = false;   // variable for keeping if the timer is running
bool Timer_OneShot = true;

HCSR04 hc(8, 9);  //initialization class HCSR04 (trig pin , echo pin)

void setup() {
  Serial.begin(9600);
  lcd.init();  // initialize the lcd
  lcd.backlight();
  // initialize the LED pin as an output:
  pinMode(ledPin, OUTPUT);
}

void loop() {
  CurrentDistance = hc.dist();      // return current distance in serial
  delay(60);                        // we suggest to use over 60ms measurement
cycle, in order to prevent trigger signal to the echo signal.
  Serial.println(CurrentDistance);  // return current distance in serial
```

```
  // Changes the State of buttonState based on 2.8 ft
  if (CurrentDistance <= 85) {
    buttonState = HIGH;
  } else {
    buttonState = LOW;
  }

  // check if the pushbutton is pressed. If it is, the buttonState is HIGH:
  if (buttonState == HIGH && buttonPreState != buttonState) {
    buttonPreState = buttonState;

    if (Start_Timer && CurrentTimePased > 59000 && Timer_OneShot) {

      if(Start_Timer){// makes timer only be started once
        Timer_OneShot = false;
        digitalWrite(ledPin, LOW);
      }
      Start_Timer = !Start_Timer;


    } else if(Timer_OneShot){
      // turn LED on:
      digitalWrite(ledPin, HIGH);
      Start_Timer = true;
    }

    if (Start_Timer && timeStart == 0) {
      timeStart = millis();


    }

  } else if (buttonState == LOW) {
    buttonPreState = buttonState;
  }

  if (Start_Timer) {
    CurrentTimePased = millis() - timeStart;
    lcd.clear();                                                // clear display
    lcd.setCursor(0, 0);                                        // move cursor to
(0, 0)
```

```
    lcd.print(String(CurrentTimePased) + String(" Millis"));  // print new time
at (0, 0)
  }
}
```

MOVING WALL:

```
#include <Servo.h>


Servo myservo;  // create servo object to control a servo
Servo myservo2; // create second servo for second wall


int pos9 = 90;    // variable to store the servo on pin 9’s position
int pos13 = 90; // variable to store the servo on pin 13’s position




void setup() {
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
  myservo2.attach(13); // attaches the servo on pin 13 to the servo object
}


void loop() {
    for (pos9 = 65; pos9 <= 180 && pos13 >=0; pos9 += 1) { // goes from 65
degrees to 180 degrees
    // in steps of 1 degree
    myservo.write(pos9);    // tell servo on pin 9 to go to position in variable
'pos9'
    myservo2.write(180 - pos9);
    delay(20);                // waits 20 ms for the servo to reach the position
  }
  delay(2000); // keeps walls open for 2000 ms for cars to pass
```

```
  //servo1 (pin9) will be at 180
  //servo2 (pin13) will be at 0

  int timer = 0; // timer variable initialized for servo attached on pin 13
  for (pos9 = 180; pos9 >= 65; pos9 -= 1) { // goes from 180 degrees to 0 degrees
    if (timer <= 100) { // loop that allows for servo on pin 13 to go from 180 to 100
      timer += 1;
      myservo2.write(timer);
    }
    myservo.write(pos9); // tell servo on pin 9 to go to position in variable 'pos9'
    delay(20);        // waits 20 ms for the servo to reach the position
  }
  delay(2000); // keeps wall closed for 2000 ms to block cars
}
```