Design Review 0

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Itinerary:

1. Introduction
    a. Attendance
        i. Meeting Leader: Toby Bradshaw
        ii. Meeting Minutes: Gavin Carr
    b. Addressing Feedback
2. System Block Diagram
    a. System Drawings
    b. Mechanical Inputs and Outputs
    c. Electrical Inputs and Outputs
    d. Finite State Machine Software Flow
    e. Complete System Block Diagram
3. System Requirements
    a. Feedback Subsystem
    b. Mechanical Subsystem
    c. Power Subsystem
    d. Obstacle Subsystem
    e. Controls Subsystem
    f. Comments
4. Written Plan for Achieving Requirements
    a. Design Review 1 Plan
    b. Design Review 2 Plan
    c. Action Plan
5. Questions
6. Conclusion

1 Introduction

Our project is the design and fabrication of a miniature pinball machine. The pinball machine will incorporate several moving parts to emulate the difficulty and excitement of the original game. A simple spring mechanism will launch the ball into the board. Buttons will be used to manipulate the paddles and keep the ball in play. With regards to obstacles, there will be two stationary targets, one moving target, one rotating paddle, and one ramp. When these are hit, the scoreboard will update, triggering images to be displayed on the OLED, audio clips to play, and lights to flash. This will provide an engaging and fun user experience. A system block diagram and system requirements will follow so they will not be expressed here.

Feedback from last semester:

1. Prototyping the mechanical portions should be early on your to do list.
    a. This is elaborated on in our plans for design review 1 and 2 plans.
2. I have concerns about using IR sensors. There is a lot of IR coming from all sorts of sources that might drown out what you are trying to sense. Something else to prototype in the expected environment. (There is a warning to this effect in the Adafruit article about using this sensor. Note that there will not be a dark room on demo day.)
    a. We are going to have a physical switch triggered when the ball makes contact with the target.
3. One great weakness of the previous attempt was the wiring. I highly recommend that each of the “devices” in the play area be connected back via a cable that has connectors that only plug in one way. Since the length will be variable, I suggest you choose a connector solution that has hand-crimpable pins since it is unlikely that you will be able to find per-crimped wires of the appropriate length.
    a. We will make wiring clarity a top priority and make sure that we document where wires should go and label them with tape to ensure good teamwork with prototyping.
4. You might want to find a pre-built power supply with the voltages you need, or even just a wall power to 12V DC supply. I’d prefer that you not use anything that is open frame.
    a. We were looking for a wall power to 12V DC supply. The last pinball group used this, but if there are none in 205 we will order one.
5. It isn’t clear if any of your obstacles (other than the spinner) are active. One of the features of most pinball machines is that hitting something accelerates the pinball.
    a. We also have a moving target, so there are two active obstacles. If necessary, we could add parts behind our rubber band bumpers (refer to Figure 1) to accelerate the ball. Is there a minimum?
6. You might consider separating the controls and the display.
    a. We are going to add another button so that the control and display subsystems are separate.
7. The display you referenced is a raw display. The “companion” driver board is $40. I assume that since it is Adafruit, appropriate drivers and libraries are available.
    a. Discuss which option would be better.

2 System Block Diagram

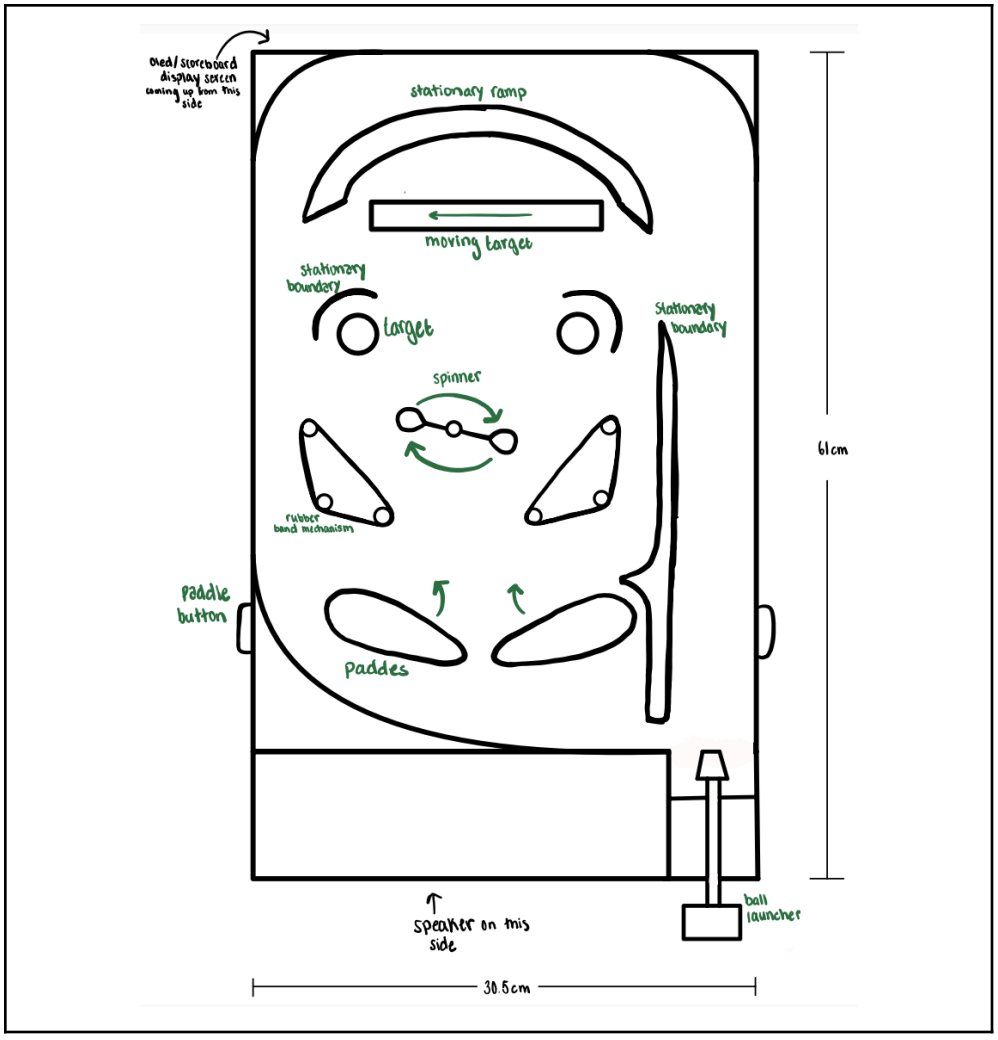

Figure 1: Surface of gameplay with minimal anticipated dimensions, x-y plane

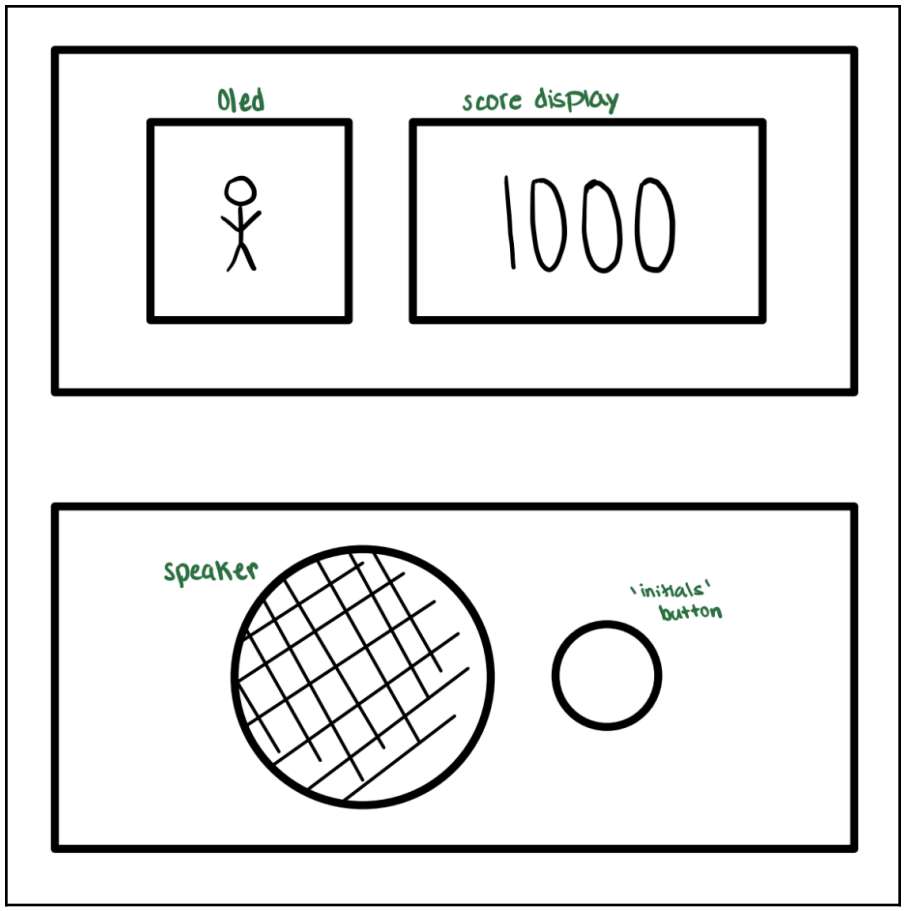

Figure 2: Visual placements of the speaker, OLED, ‘Initials’ Button, and 7 segment display,
x-z plane

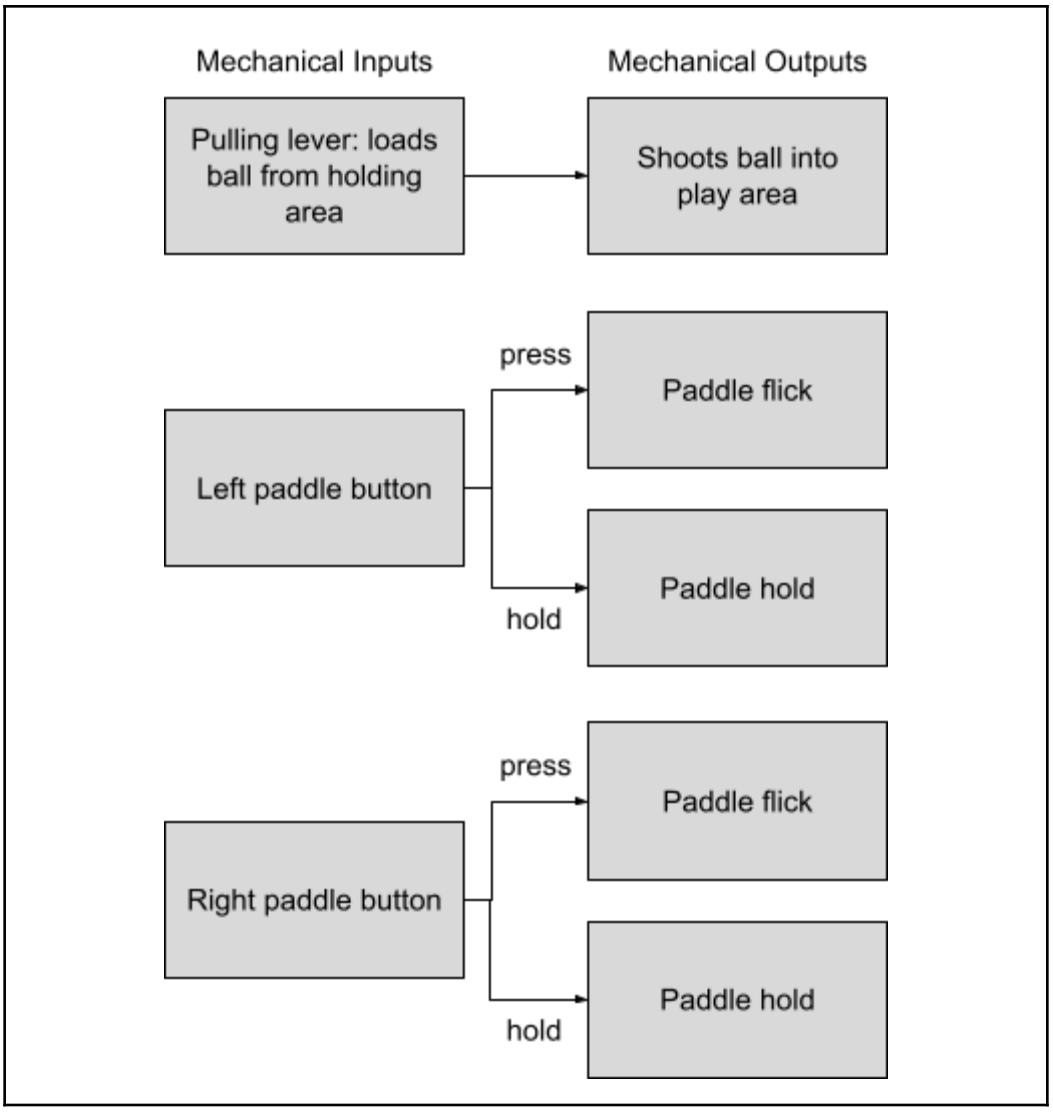

Figure 3: Mechanical Inputs and Outputs for Paddles and Spring Loaded Launcher

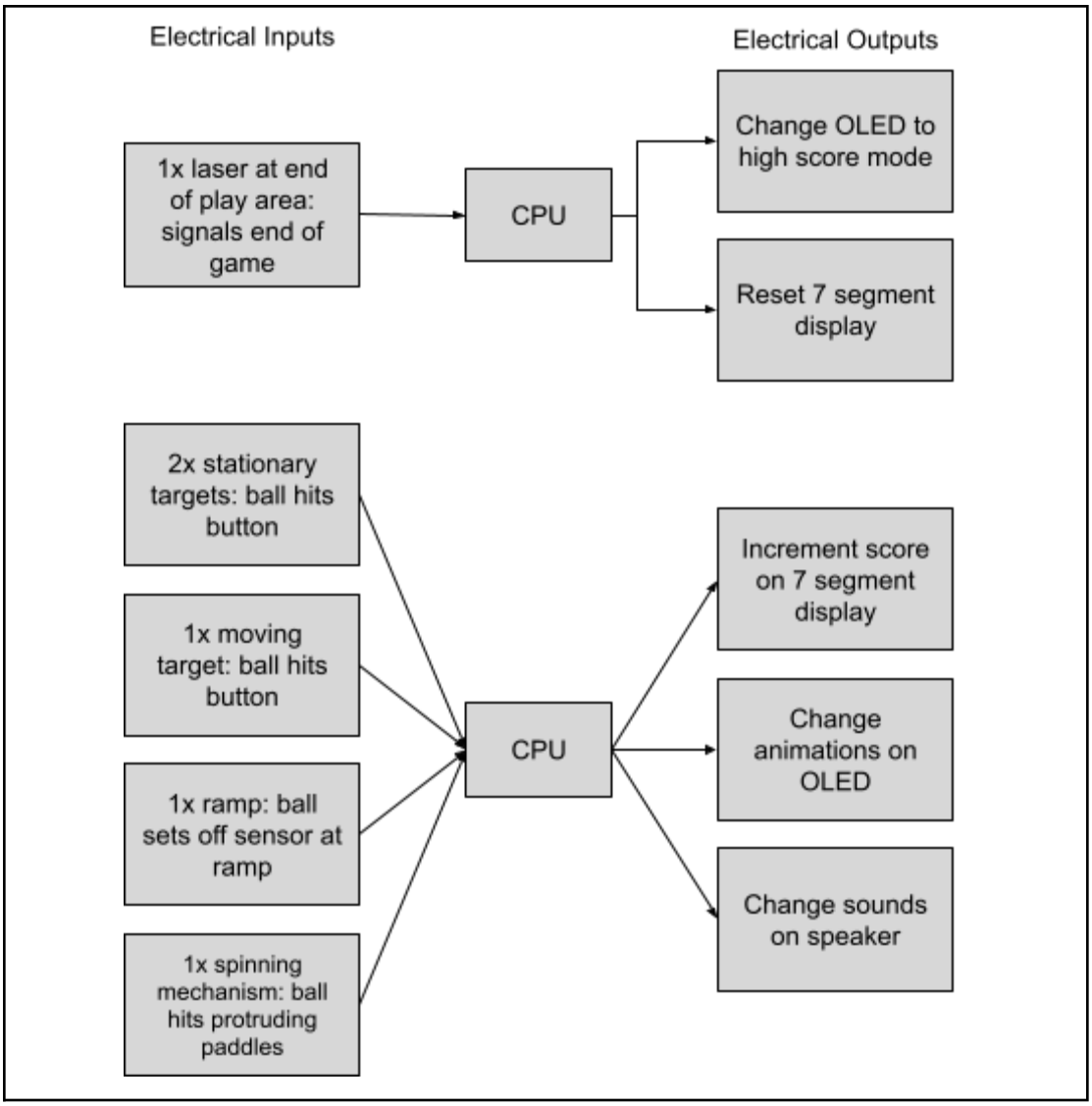

Figure 4: Electrical Inputs and Outputs for Targets and Display

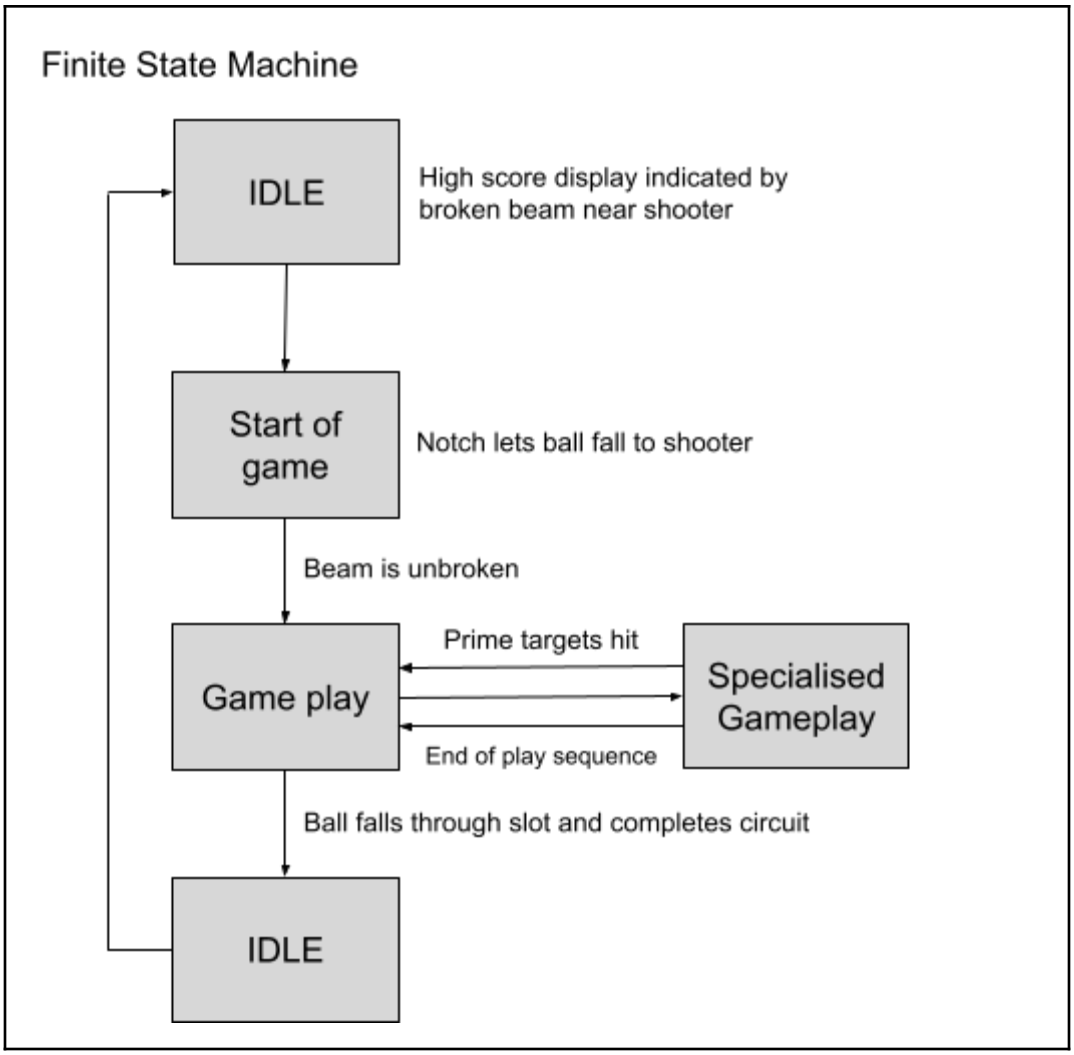

Figure 5: Finite State Machine Software Flow

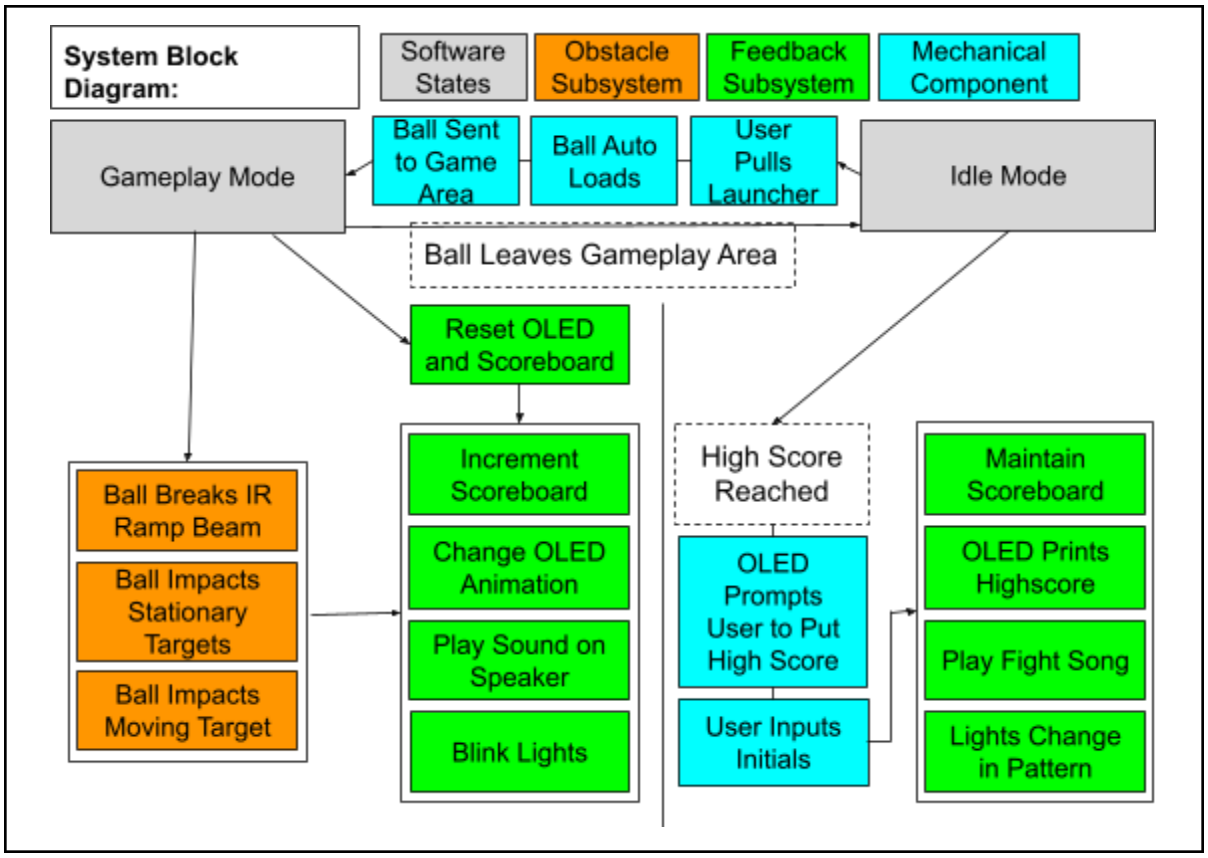

Figure 6: Complete System Block Diagram

3 List of Requirements for Each Subsystem

The overall system will be composed of 5 major subsystems: Feedback, Mechanical, Power, Controls, and Obstacle. However, the feedback and obstacle subsystems are composed of multiple different parts which all must be controlled by the microcontroller.

Feedback Subsystem:

1. OLED and 7 Segment Display
    a. Design Requirements:
        i. Different states for idle and gameplay modes. These modes will be determined by the microcontroller.
            1. Idle:
                a. The OLED will display high scores
            2. Gameplay:
                a. The OLED will display image animations in real time
                b. The 7 segment display will update the score in real time
        ii. Data Communication
            1. Data will be sent to the OLED over Serial Peripheral Interface (SPI)
            2. Data will be sent to the 7 segment display over SPI or I2C

b. Dependencies:
    i. Requires input from microcontroller to determine state (idle or gameplay)
    ii. Requires input from the initial's input buttons for players to record high scores
c. Unknowns:
    i. Exact power required for each
    ii. Additional microcontroller specifications for OLED display

2. Audio
    a. Design Requirements:
        i. Different states for idle and gameplay modes. These modes will be determined by the microcontroller.
            1. Idle:
                a. Speaker will produce the Notre Dame fight song
            2. Gameplay:
                a. MCU will send short mp3 files to be played in real time during gameplay in response to obstacles being hit
                b. MCU will send short mp3 files to be played in real time during gameplay in response to the gameplay ending
        ii. Data will be sent from the microcontroller to the Audio Subsystem over Inter-Integrated Circuit Sound (I2S).
    b. Dependencies:
        i. Requires input from microcontroller to determine state
    c. Unknowns:
        i. Exact power required
        ii. Whether we will need an external DAC / amplifier (will the board have a basic DAC built-in and will it have sufficient power to drive the speaker directly or will we get external pieces)

3. Lighting
    a. Design Requirements:
        i. Different states for idle and gameplay modes. These modes will be determined by the microcontroller.
            1. Idle:
                a. The single LEDs will have a coordinated blinking pattern
                b. The LED strip will have a patterned lighting sequence
            2. Gameplay:
                a. Obstacle LEDs will be triggered to blink from the microcontroller after the assigned obstacle is triggered
                b. LED strip will remain on – though not blinking – around the border of the game
        ii. Individual LEDs will be placed and assigned to stationary obstacles.
        iii. A light strip will be placed around the border of the game
    b. Dependencies:
        i. Requires input from microcontroller to determine state and send commands to the LEDs for real-time reactions

c. Unknowns:
    i. How to interface the LED strip with the microcontroller
    ii. Exact power requirements – ensure the LED subsystem does not demand higher current than the microcontroller can provide

Mechanical Subsystem:

4. Spring-Loaded Launcher
    a. Requirements:
        i. Pulling back the spring-loaded launcher will move the pinball into position and will start gameplay
        ii. When inert (not pulled back), the launcher should stop the ball from leaving the holding area unintentionally
    b. Dependencies:
        i. The enclosure must be constructed to house the launcher and the holding area properly
        ii. The holding area must have a circuit able to be completed by the ball to register when it is in position
5. Paddles
    a. Requirements:
        i. The Paddle Subsystem is split into two identical subsystems: Left Paddle Subsystem and Right Paddle Subsystem
            1. The Left Paddle Subsystem consists of the left 3D printed paddle, left solenoid actuator, and left button
            2. The Right Paddle Subsystem consists of the right 3D printed paddle, right solenoid actuator, and right button
        ii. Paddle Functionality
            1. When the button is pressed and held, the paddle will remain in an upright position
            2. When the button is pressed quickly, the paddle will flip upward then immediately return to the stationary position
        iii. The paddles will be placed far enough apart on the gameplay surface to allow the pinball to fall through the gap between them
    b. Dependencies:
        i. The enclosure must be built to support proper placement and alignment
        ii. Power supply must be able to operate the solenoid actuators without overheating or voltage drops – ensure power supply can handle the peak current demand of both solenoids simultaneously through use of capacitors
    c. Unknowns:
        i. Size of the paddles, which depends on the size of other obstacles/enclosure/etc.
        ii. Power demand for the paddle subsystem
        iii. How will button debouncing be handled
6. Enclosure

a. The gameplay surface will be at an angle between 6 degrees and 7.5 degrees, per convention
b. There will be a buffer box at the front of the enclosure that encases the speaker and the spring-loaded launcher
c. There will be some enclosure underneath the surface of gameplay for electronics, wires, and electromechanical components of the subsystems. We will need to carefully organize wiring
d. Unknowns
    i. Material selection: see questions below

Power Subsystem:

7. Power
    a. Requirements:
        i. A power adapter will be plugged into the wall
        ii. The main power supply of the pinball machine will be plugged into the adapter to power the microcontroller
        iii. The microcontroller will use 12V to power the Paddle Subsystem and the Audio Subsystem
        iv. The microcontroller will include a step-down circuit to 5V to power the Display Subsystem
        v. The microcontroller will include a step-down circuit to 3.3V to power the remaining components on the microcontroller, the lighting subsystem, and the Obstacle Subsystem
        vi. Capacitors for power smoothing
    b. Dependencies:
        i. Connections to all necessary outputs: obstacle subsystem, microcontroller, and display subsystem
        ii. Available connection to wall outlet
        iii. Ensure the total power demand does not exceed the capacity of the power adapter or step down circuits
    c. Unknowns:
        i. Detailed power calculations for the necessary power to each subsystem, including voltage and current draw of individual components and peak power demands for components like solenoids and the audio system

Obstacle Subsystem:

8. Stationary Obstacles:
    a. Requirements:
        i. The stationary targets consist of a 3D printed target and a button behind the target
        ii. Wire ramp obstacle consists of a structure that moves a pinball in motion from one side of the playing field to another and an IR Break Beam sensor. This sensor must be enclosed to deflect outside interference

iii. Sensors in stationary obstacles will send signals to the microcontroller when triggered.

b. Dependencies:
   i. Outputs to interface with the microcontroller
   ii. Power for buttons

9. Moving Obstacle:
   a. Requirements:
      i. The moving obstacle system will consist of a motorized slide potentiometer, a 3D printed circle, and an IR Beam Break sensor.
      ii. The 3D printed circle will have a diameter larger than the pinball.
      iii. The 3D printed circle will have mounts for the IR Beam Break sensor, IR Beam Break receiver, and the motorized slide potentiometer.
      iv. An additional rubber track or stopper will be added to ensure the pinball doesn't get stuck in the cutout for the motorized slide potentiometer.
   b. Dependencies:
      i. Power for the motor
      ii. Connection to the microcontroller to control the speed

Controls Subsystem:

10. Software:
    a. Design Requirements:
       i. The software will have two modes: gameplay and idle, and it will be able to switch between these modes based on the state of the ball.
       ii. It will switch to gameplay mode when the lever is pulled and the ball leaves the gameplay area.
           1. Gameplay Mode:
              a. The MCU will print images to the OLED.
              b. The MCU will play sound effects on the speaker.
              c. The MCU will update the score on the seven digit display.
              d. It will switch to idle mode when the ball is detected in the holding area.
           2. Idle Mode:
              a. The MCU will check if the player achieved a high score. If so, it will change the buttons for the paddles to increment and select the player's initials.
              b. If the player begins another game before inputting their initials, it will be recorded as "XXX" and the game will switch back to gameplay mode.
              c. The MCU will switch the score to zero.
              d. The MCU will play the Notre Dame fight song.
              e. The MCU will flash the lights intermittently.
       iii. The code will be able to run on memory allocated by MCU
    b. Dependencies:
       i. Microcontroller Layout and architecture

11. Microcontroller:
    a. Requirements:
        i. Pin connections for each obstacle to register a high or low signal to determine if something has been hit (two stationary, one moving, one ramp)
        ii. Pin connections for the moving obstacle motor to control speed and direction
        iii. Pin connections for the spinning obstacle to control the speed of rotation
        iv. Pin connections for the speaker
        v. SPI interface for the OLED
        vi. I2C interface for the seven segment display
        vii. Enough memory to store short songs and sound bites for the audio as well as short animations for the OLED
    b. Unknowns:
        i. How to control the motors
        ii. SPI or I2C for seven segment display
        iii. Possible additional SPI connection for OLED driver board

Comments on Requirements:

We will need to spend extra time coordinating the motor control as we have not worked with them often. Further, we need to come to a consensus on what OLED to use as that will affect the design of our board. Furthermore, we should make detailed power calculations a high priority and use that to make more accurate decisions over what parts to buy. We should be able to verify that all the display subsystems can work with kit boards from class but we will have to have our board made to verify that they all work in unison as well as in response to the external inputs. Therefore, we should do our best to troubleshoot the parts of the display individually to save time compiling the entire system.

4 Written Plan for Achieving the Requirements of Design Reviews 1 and 2

Design Review 1 Plan:

We will start by critically evaluating each of the parts we had previously selected to ensure availability and verify requirements. We will then create detailed power calculations to ensure that we will be able to power each subsystem. We will split up each of the subsystems for each of the group members to create designs for. We will then have a group meeting a week before Design Review 1 in order to verify that each design is realistic, buildable, and has a plan to be fabricated. We will do this by redividing the subsystems and verifying each other's work independently. Each design should include not only the specifications and build of the subsystem but also detailed drawings, necessary connections, and MCU interface requirements. From there, we will then be able to accurately define what our microcontroller must need and can begin work on that design. For the microcontroller and code, we should have an accurate idea of clocking, voltage, current, and memory requirements from our individual designs and part specifications. Each of these designs, their progress, assigned

members, and other notes will be kept track of in our action items spreadsheet as shown at the bottom of this document.

Design Review 2 Plan:

We will start by having our treasurer, Gavin, order each of the parts specified. Ideally this could be started before or immediately following Design Review 1 to allow for shipping times as well as maximum time to complete our designs. Immediately following feedback from Design Review 1, we will begin work on our board design. We will again do this by assigning each subsystem to a different group member with one member working on the board. It would also be effective to group members according to the subsystem they are working on such that we already have an accurate idea of how the parts could be assembled. Furthermore, a week prior to Design Review 2, we will have a private meeting where we verify each subsystem will work and troubleshoot as a group. Finally, we will gather before the review itself to get everything set up and have a plan to move through the review as efficiently as possible. Each of these actions will be kept track of in the action plan as shown below.

Item Description	Status	Assigned Members	Due date	Date Completed	Dependencies	Notes
System Block Diagram	Completed	Toby Bradshaw	1/23/2025	1/21/2025		Best understood in relation to the other diagrams we have
List of Requirements For Each Subsystem	Completed	Toby Bradshaw Clare Nick	1/23/2025	1/22/2025		Notes
Written Plan for Future Design Reviews	Completed	Toby Bradshaw	1/23/2025	1/22/2025		Notes
DESIGN REVIEW 0	Deadline	Toby Bradshaw	1/23/2025			Notes
Submit Notes for Design Review 0	Deadline	Gavin Carr	1/22/2025			Notes
Power Calculations	Not started		1/30/2025			Notes
Pick Parts	Not started		1/30/2025			Notes
OLED and 7 Segment Detailed Design	Not started		2/13/2025			Notes
Audio Detailed Design	Not started		2/13/2025			Notes
Lighting Detailed Design	Not started		2/13/2025			Notes
Detailed Description of Major Componenets	Not started		2/13/2025			Notes
Spring Loaded Launcher Detailed Design	Not started		2/13/2025			Notes
Paddles Detailed Design	Not started		2/13/2025			Notes
Enclosure Detailed Design	Not started		2/13/2025			Notes
Power Detailed Design	Not started		2/13/2025			Notes
Stationary Obstacles Detailed Design	Not started		2/13/2025			Notes
Moving Obstacles Detailed Design	Not started		2/13/2025			Notes
Compiled List of Microcontroller Specifications	Not started		2/13/2025			Notes
Action Plan to Solve Issues	Not started		2/13/2025			Notes
DESIGN REVIEW 1	Deadline	Gavin Carr	2/20/2025			Notes
Submit Notes for Design Review 1	Deadline	Allison Flemming	2/20/2025			Notes
Purchase Parts	Not started		m/d/yyyy			Notes
Design Board	Not started		m/d/yyyy			Notes
Item Description			m/d/yyyy			Notes
Item Description			m/d/yyyy			Notes
Item Description			m/d/yyyy			Notes
Item Description			m/d/yyyy			Notes

Figure 7: Action Plan

5 Questions

1. Does the EIH have the material we use for the water jet cutter / do we have to pay for it?
2. Can we take a speaker from the closet? There are so many with wildly different prices.
3. Per Professor Schafer's feedback, is there a minimum number of active obstacles? Do we have enough?
4. Will we be able to avoid interference for IR beams by simply covering them?

5. Would you recommend using an OLED with an external board or should we try and include that in our board design?
6. Would it be a better idea to have a separate start button to load the ball and start the game or should we stick to our plan to have it be operated by pulling back the lever?