Sensors And Metrology
Milestone 2 Report
Automated Hand Sanitizer Dispenser

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1. Hardware Design and Fabrication

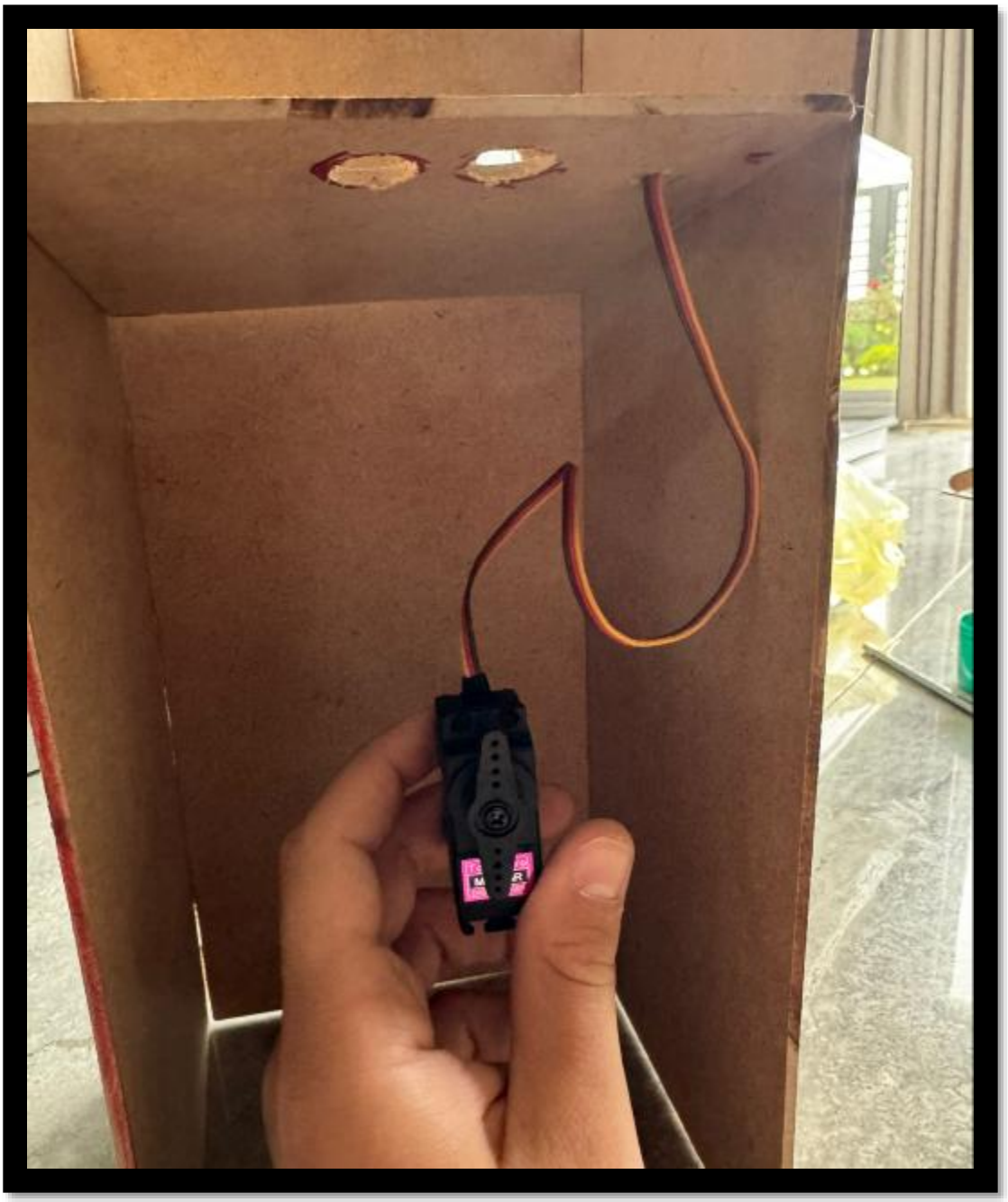
1.1 Mechanical Design Process

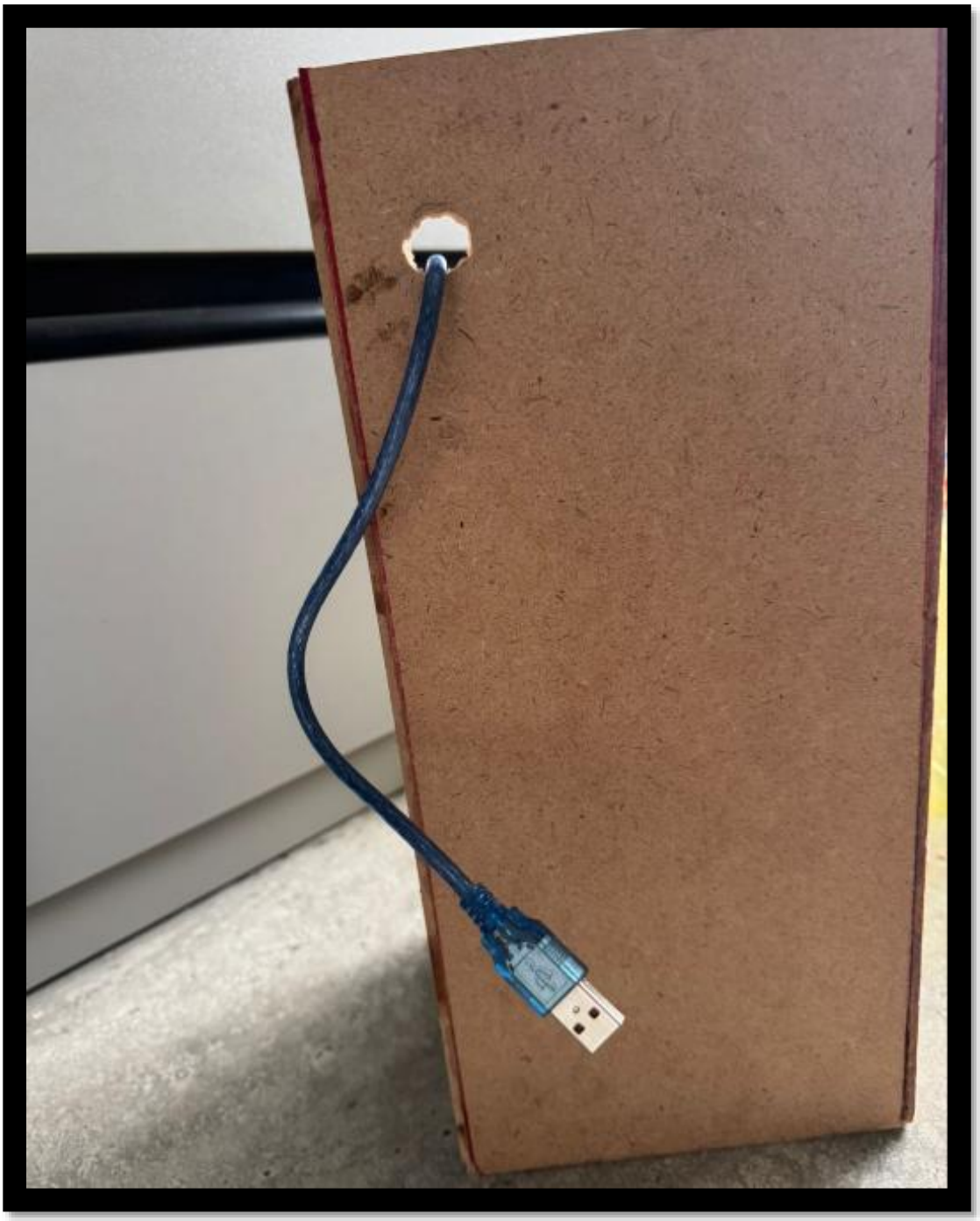
The mechanical housing was fabricated entirely from wood. The process began by planning the dimensions needed to hold the ultrasonic sensor, sanitizer bottle, servo mechanism, and Arduino board. After finalizing the layout, wooden panels were measured, cut, and shaped to form the external frame and internal mounting surfaces.

Design stages:

1. Cutting wooden panels for the front, sides and top sections of the dispenser.

2. Fabrication of the front panel with cutouts for the Ultrasonic sensor, Servo, USB cable, wires and bottle viewing window






ARDUINO
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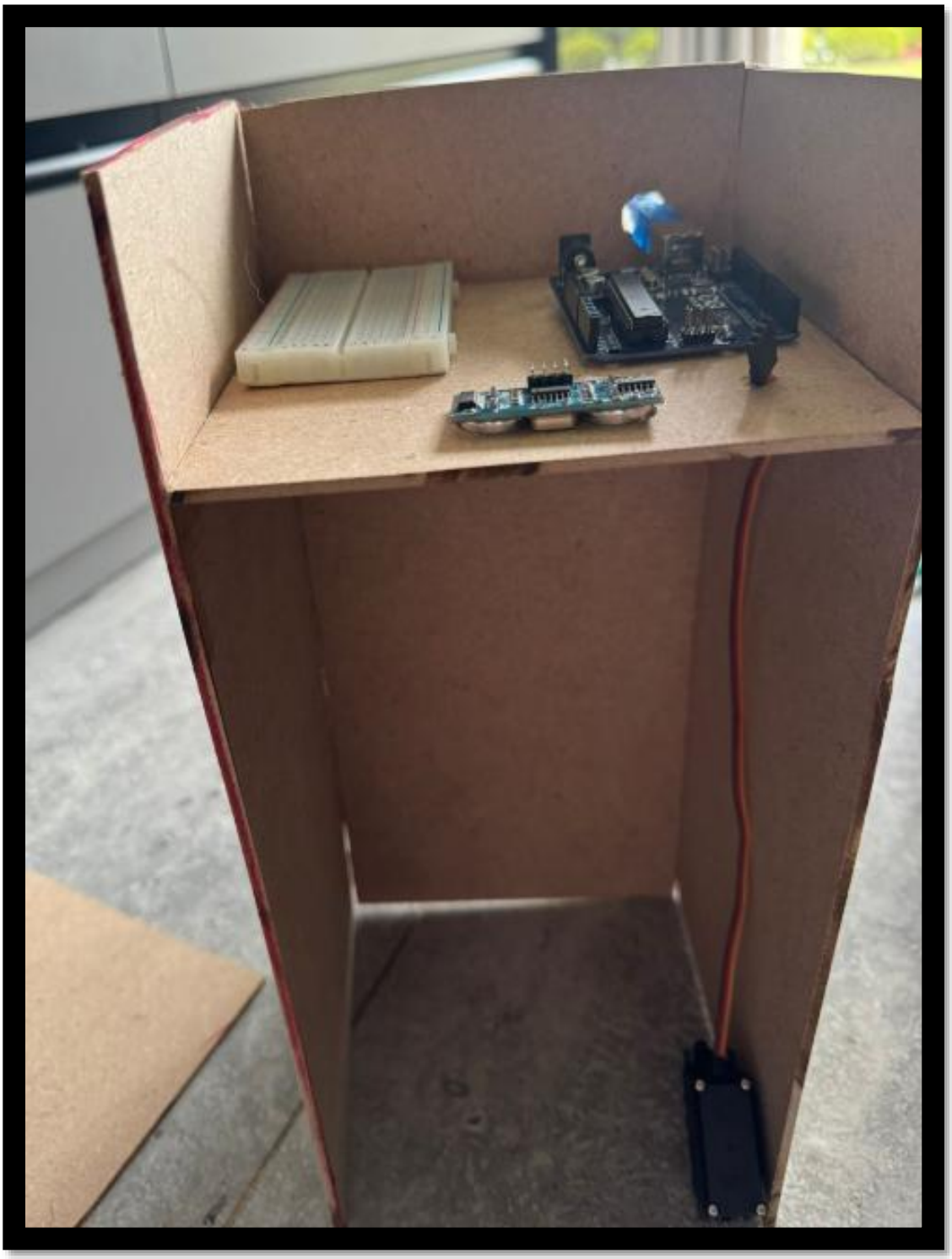
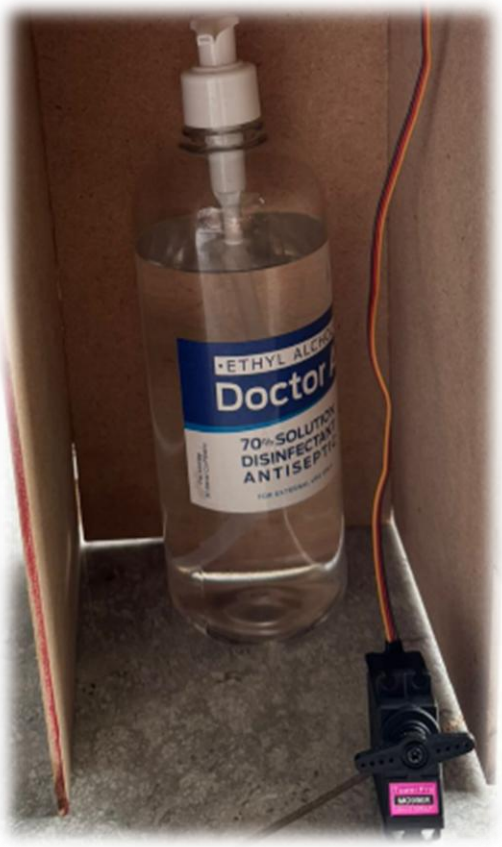


3. Creation of a servo mounting bracket placed directly above the sanitizer pump.



4. Final assembly of all structural elements into a stable upright frame.


HAND
SANITIZER

1.2 Electronic Design Process

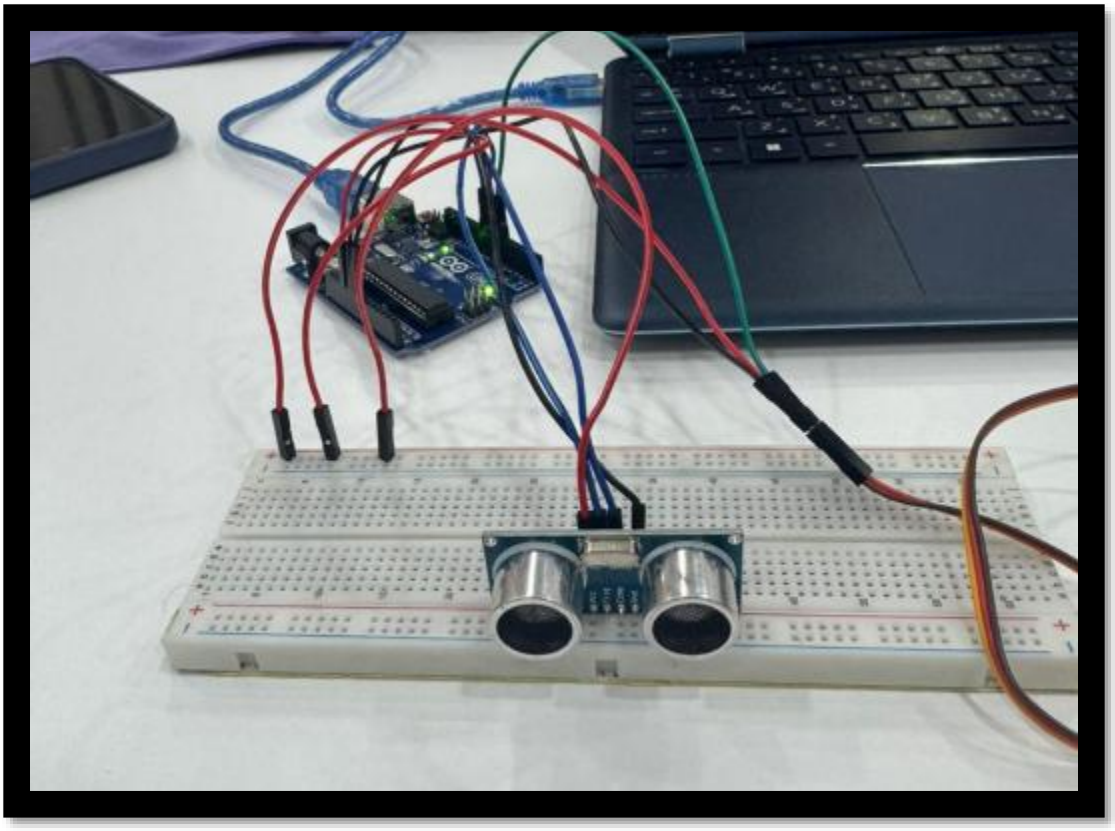
The electronic design followed a modular approach:

- Ultrasonic sensor connected to Arduino for hand detection.
- Servo motor connected to Arduino to actuate the dispensing mechanism.
- Power distribution through Arduino 5V and GND rails.
- All components tested individually before full system integration.

1.3 Materials and Tools

Materials Used:

- Ultrasonic Sensor (HC-SR04)
- MG996R Servo
- Arduino Uno
- Frame material (wood)



2. System Assembly

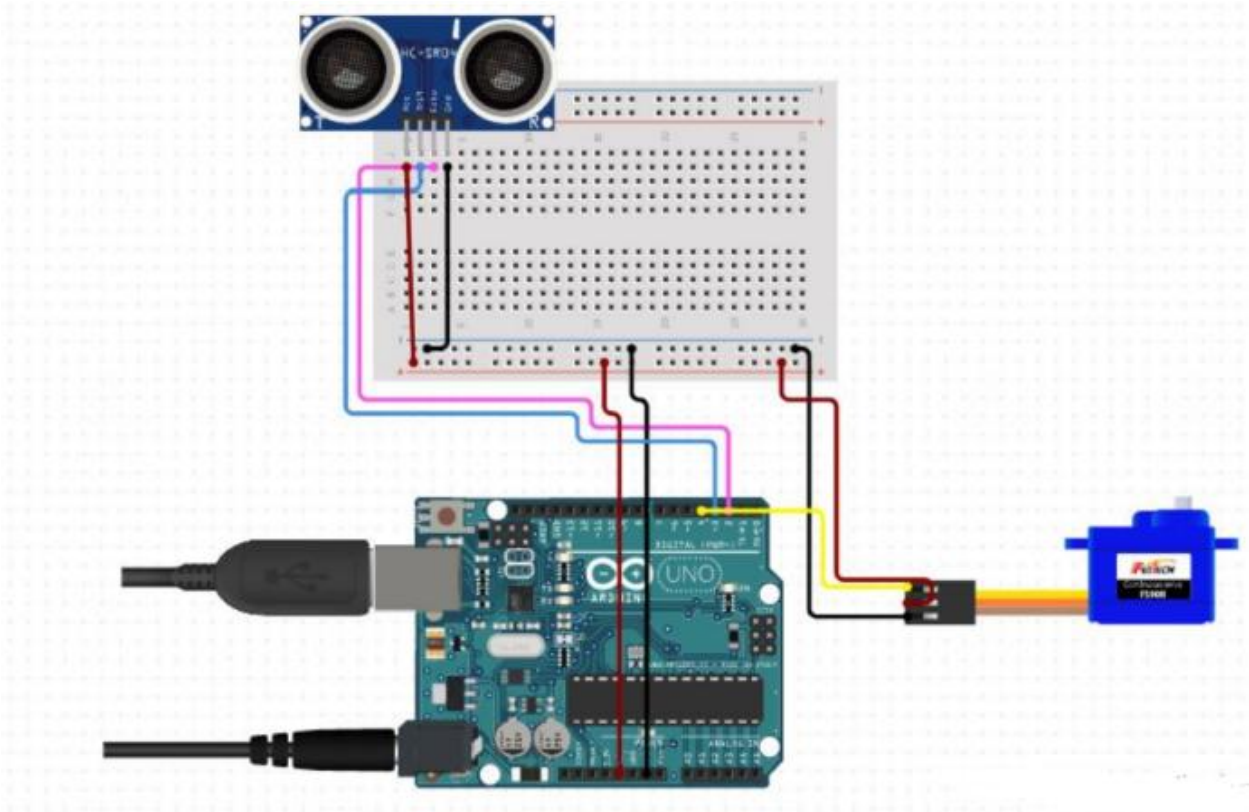
2.1 Assembly Process

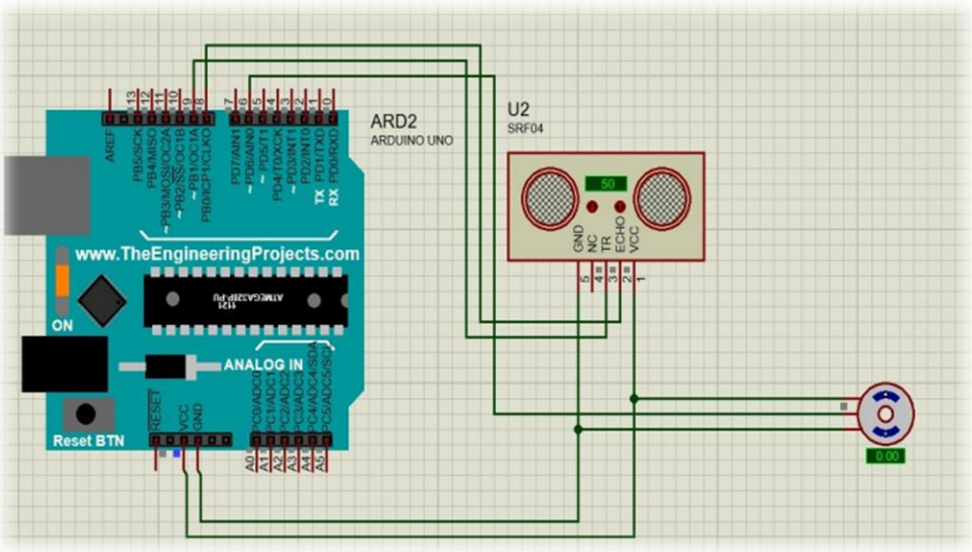
The assembly process focused on creating a stable, accurately aligned structure that ensures reliable sensor detection and smooth servo actuation. The steps followed were:

1. The ultrasonic sensor was mounted on the front panel facing outward.
2. The servo motor was installed above the sanitizer bottle, aligned with the pump head.
3. The Arduino board was fixed onto the base platform.
4. All wiring connections were routed and secured to avoid movement during servo operation.

2.2 Component Integration

- The ultrasonic sensor (TRIG and ECHO pins) was connected to the Arduino.
- The servo was connected to a PWM pin to allow controlled actuation.
- The bottle was placed securely below the servo so the lever arm presses the pump head.





2.3 Critical Assembly Notes

- Ensured the servo horn is centered before attaching the lever arm.
- The ultrasonic sensor faced forward with no obstructions.
- Wiring tightened and fixed to avoid disconnection during servo motion.

3. Full System Operation

3.1 Arduino Code Explanation

The updated Arduino code uses the NewPing library, which makes the ultrasonic sensor faster and more stable than the normal pulseIn method. The code handles three simple jobs: reading distance, checking for a hand, and pressing the sanitizer pump.

1. Distance Measurement

The HC-SR04 ultrasonic sensor is read using sonar.ping_cm().
This function sends the trigger pulse and gives the distance in centimeters directly.
Whenever the reading is above zero, the distance is printed on the Serial Monitor.

2. Hand Detection Cooldown

The system looks for anything **20 cm or closer**, which represents a hand.
To stop the dispenser from spamming the servo repeatedly, the code uses a lockout timer.
The time when the last press happened is stored in lastDispenseTime.
The servo only activates again if the current time (from millis()) is greater than the lockout period (1500 ms).

3. Servo Actuation

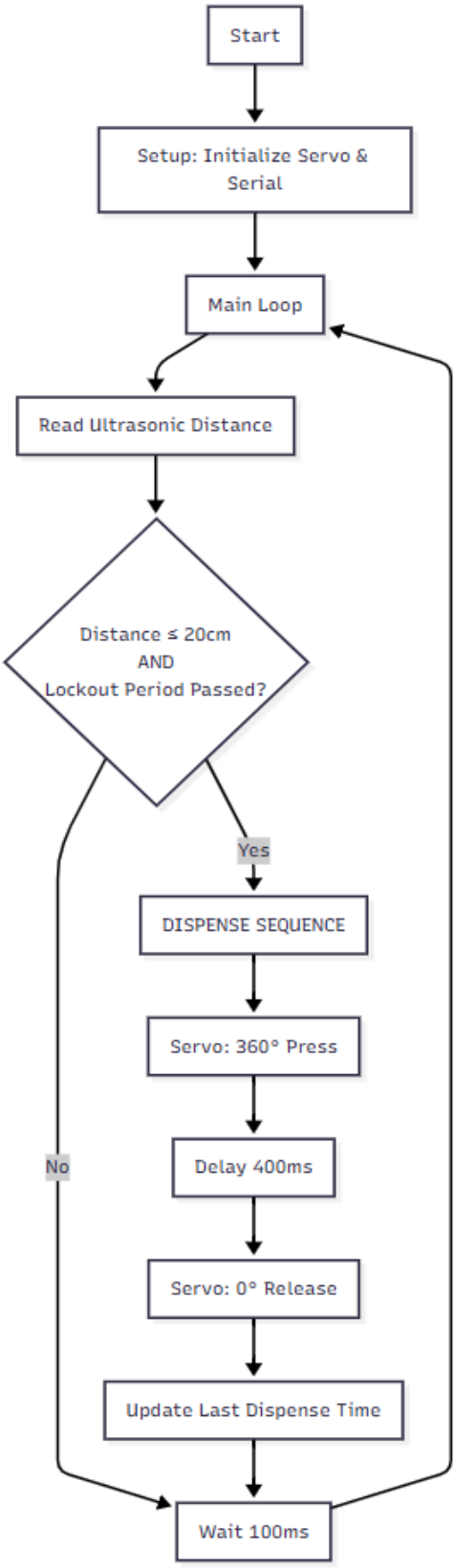
When a hand is detected and the cooldown has passed, the function dispenseSanitizer() runs.
Inside this function, the servo moves to the press position, stays there for 400 ms to push the pump, and then returns back to the release position.

Arduino Code (Used in Milestone 2)

```
// SAME CODE USING NEW PING

#include <Servo.h>
#include <NewPing.h>

Servo dispenserServo;
 float lastDispenseTime = 0;

int TRIG_PIN = 9; //initialized to pin 9 on arduino
int ECHO_PIN = 8; //initialized to pin 8 on arduino
int SERVO_PIN = 6; //initialized to pin 6 on arduino
int MAX_DISTANCE =200;
NewPing sonar(TRIG_PIN, ECHO_PIN, MAX_DISTANCE); // function of newping

int HAND_DISTANCE_CM = 20 ;
int PRESS_ANGLE = 90 ;
int RELEASE_ANGLE = 0 ;
int PRESS_TIME_MS = 400;
int LOCKOUT_TIME_MS =1500 ;
   // Max distance to measure (cm)

void setup() {
  Serial.begin(9600);

  dispenserServo.attach(SERVO_PIN); // Activates Servo
  dispenserServo.write(RELEASE_ANGLE);   // Moves the Servo
  Serial.println("Servo + NewPing ready"); // Prints when code is uploaded
}
```

```
void loop() {
  unsigned int distance = sonar.ping_cm();  // NewPing distance read

  if (distance > 0) {
    Serial.print("Distance:");
    Serial.print(distance);
    Serial.println("cm");
  }

  if (distance > 0 && distance <= HAND_DISTANCE_CM) {
// millis() returns the number of milliseconds the arduino started running
// lastDispenseTime stores the time when sanitizer last dispensed
// if function to prevent the sanitizer from dispensing repeatedly non-stop

    if (millis() - lastDispenseTime > LOCKOUT_TIME_MS) {
      dispenseSanitizer(); // calling function
      lastDispenseTime = millis();  // record the time so we can enforce cooldown
    }
  }
  delay(100);
}

// -------- Servo Action Function --------
void dispenseSanitizer() {
  Serial.println("Dispensing sanitizer");

// moves servo
  dispenserServo.write(PRESS_ANGLE);
  // delay
  delay(PRESS_TIME_MS);
  // returns to its original position
  dispenserServo.write(RELEASE_ANGLE);
}
```

3.2 Flowchart



3.3 Operating Procedure

How to Start the System

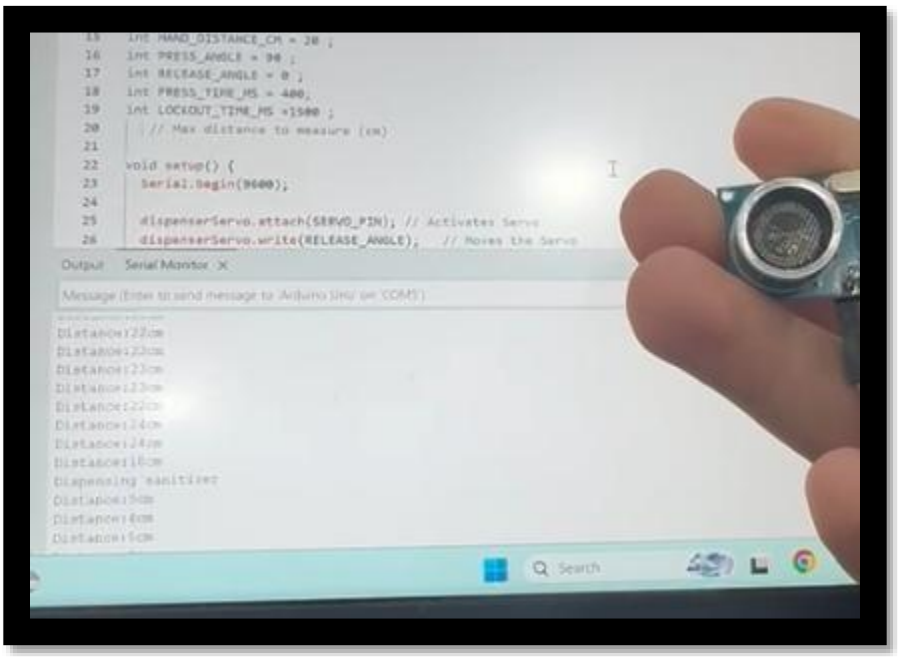
- Power the Arduino through USB or a 5V adapter.
- Ensure servo arm is in rest position before system starts.
- Open Serial Monitor (9600 baud) to view sensor readings.

Expected Actuator Behavior

- Servo moves to 90 degrees for 400 ms when a hand is detected.
- Servo returns to 0 degrees immediately after.
- System waits 1.5 seconds before next possible activation.

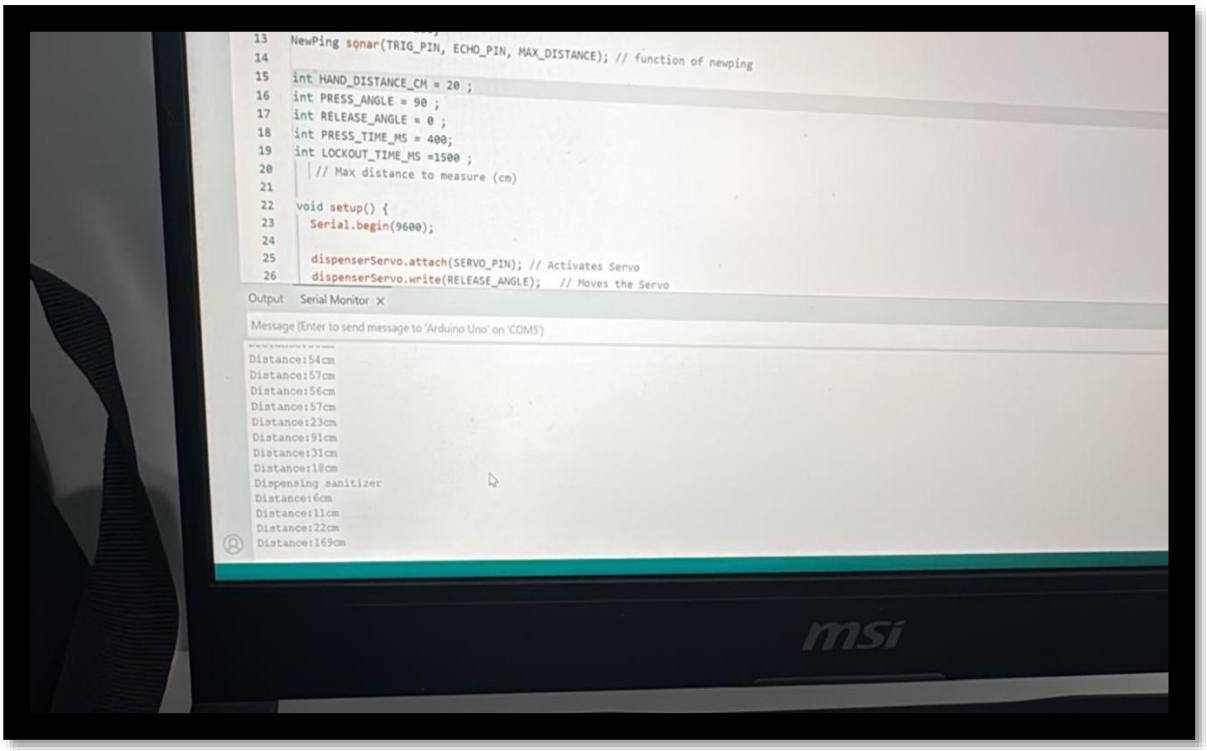
Expected Sensor Readings

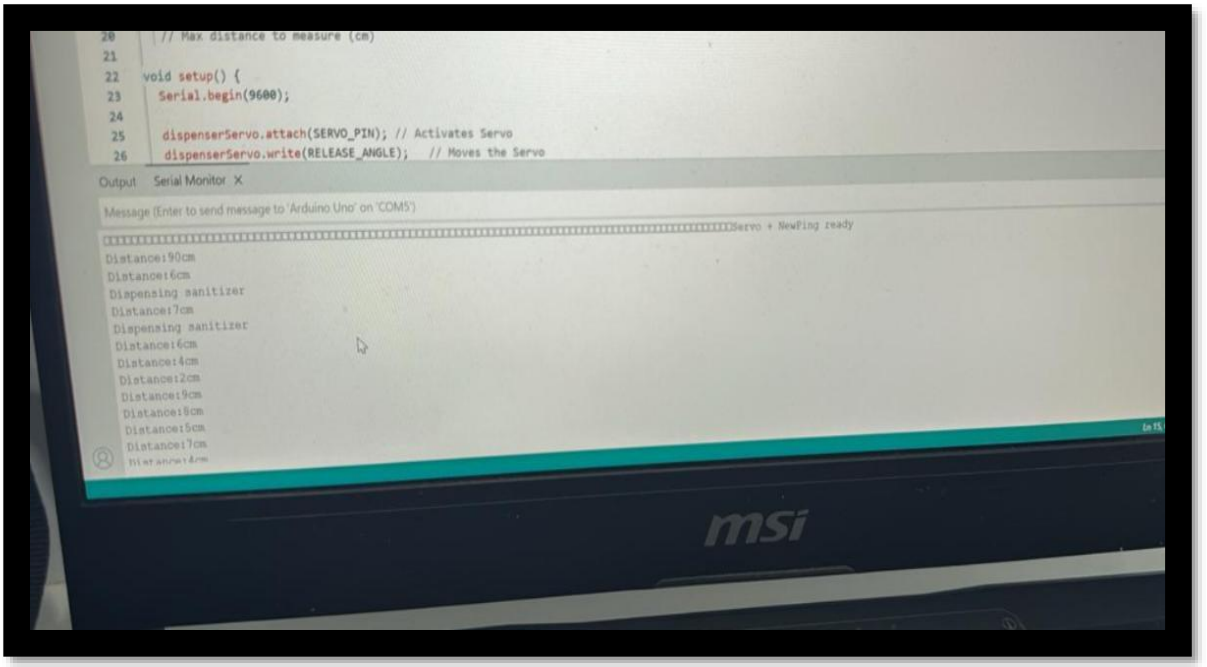
- Typical hand detection range: **5–20 cm**
- Distance is printed continuously in Serial Monitor.



3.4 Serial Monitor

Serial Monitor screenshots:





4. Sensor Characteristics and Justification

4.1 HC-SR04 Ultrasonic Sensor

- **Sensitivity:** Detects changes as small as 0.3 cm
- **Resolution:** ~3 mm
- **Accuracy:** ±1 cm under typical indoor conditions
- **Range:** 2 cm to 400 cm

4.2 MG996R Servo Motor

- **Rotation Range:** Standard ~180 degrees
- **Speed:** ~0.17–0.19 s per 60 degrees depending on voltage
- **Torque:** ~9.4 kg·cm at 4.8 V, ~11 kg·cm at 6 V (high torque for pressing sanitizer pump)
- **Accuracy:** Improved center and deadband stability due to metal gears and upgraded internal control circuitry

4.3 Justification of Selection

- HC-SR04 has ideal detection range for hand-distance sensing.
- Servo torque is enough to press most sanitizer bottle pumps.
- Both components are inexpensive and widely available.
- Fast response time matches real-time user interaction needs.

5. Results and Observations

- System successfully detects a hand in front of the ultrasonic sensor.
- Servo actuates reliably without stalling.
- Averaged distance measurement reduces noise significantly.
- Lockout timer prevents accidental double dispensing.

6. Summary

This milestone demonstrates full hardware operation, verified sensor readings, and functional actuator control. The system is ready for final refinement, improved mechanical design, and testing scenarios required for Milestone 2.