International Institute of Information Technology

Simple Pendulum

Presentation by **Team Four Sure**

TEAM FOUR SURE

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Problems

Problem 1

Real-time monitoring and visualization of pendulum motion parameters such as length, time period, amplitude, and velocity.

Problem 2

Successful implementation of remote control capabilities to adjust experiment parameters and monitor progress

Problem 3

Accurate calculation of the acceleration due to gravity based on collected data and comparison with theoretical values

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Overview

- Hardware - components and model
- Software - code and explanation
- Communication Protocol - Blynk
- Final set up - execution
- Measuring ‘g’ - acceleration due to gravity
- Change in length and calculation of ‘g’

Approach

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Our approach for the given problem statement involves the following:

1) Provide momentum to the pendulum string using swinging action of motor

2) Calculating time period using sensor and further calculating the time period

3) Connecting microcontroller to the communication protocol and remotely calculating the value of ‘g’ - acceleration due to gravity

4) Performing Length change using Servo motor

COMPONENTS

Initiating Pendulum Motion & Length change

To initiate pendulum motion, we will use a servo motor controlled by a microcontroller. The servo motor will be connected to a flap, which will strike the bob with sufficient force to start its swing. We intend for the flap to move according to the length of the pendulum so that it can strike the bob at any possible position. Alternatively, we can use a flap of the same length as our pendulum stand, ensuring it strikes the bob regardless of its position.

Measuring Time Period

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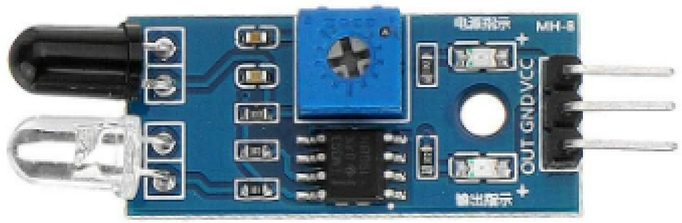
- For measuring the time period of a simple pendulum, we used **Infrared sensors**.
- The IR transmitter continuously emits the IR light and the IR receiver keeps on checking for the reflected light. If the light gets reflected back by hitting any object in front it, the IR receiver receives this light. This way the object is detected in the case of the IR sensor.

  By using,

  we can calculate the Time period of the pendulum
- This will also be used to calculate the length of the string.
- Further using this, time period we can compute ‘g’ as: g = ((4 * 3.141 * 3.141 * length) / (time_period)



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Microcontroller and communication protocol

- We are using ESP8266 microcontroller.
- Wi-Fi Connectivity: The ESP8266 module has built-in Wi-Fi capabilities, allowing it to connect to local networks or the internet. This feature is valuable for remote monitoring and control of experiments. Data collected by sensors can be transmitted wirelessly to a server or cloud platform for analysis or storage.
- The ESP8266 is a low-cost microcontroller with powerful features, making it an affordable choice for experimental setups compared to more expensive data acquisition systems. This makes it accessible for educational purposes or small-scale research projects.Built in Wi-Fi:TCP/IP and UDPw.

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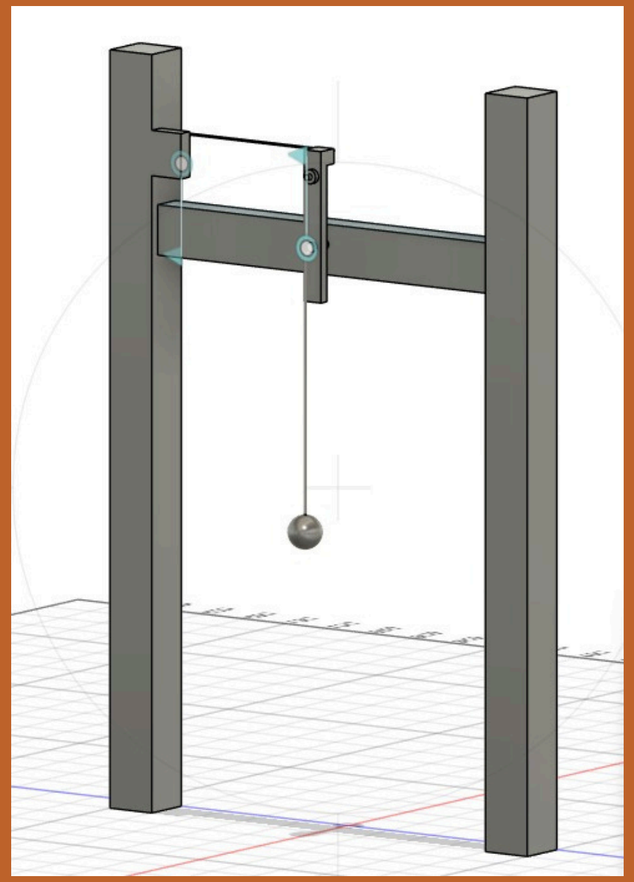
HARDWARE



1) The hardware model that we are currently using is shown here. It primarily consists of a wooden stand with a small wooden rod.
2) This wooden rod is connected to sevo motor through a 3-d printed flap. The servo motor will give a nudge to the wooden rod which will eventually give momentum to the bob through the string attached to it.
3) The rod will eventually stop motion as therre will be no further movement by sevo.
4) There will be a stepper motor connected at the wooden clamp connected to the string with Bob. This will help in Changing the length of pendulum.
5) With the use of IR Sensor at the bottom, we will be able to find Time period.
6) With this calculated time period we will find the value of ‘g’ - acceleration due to gravity.

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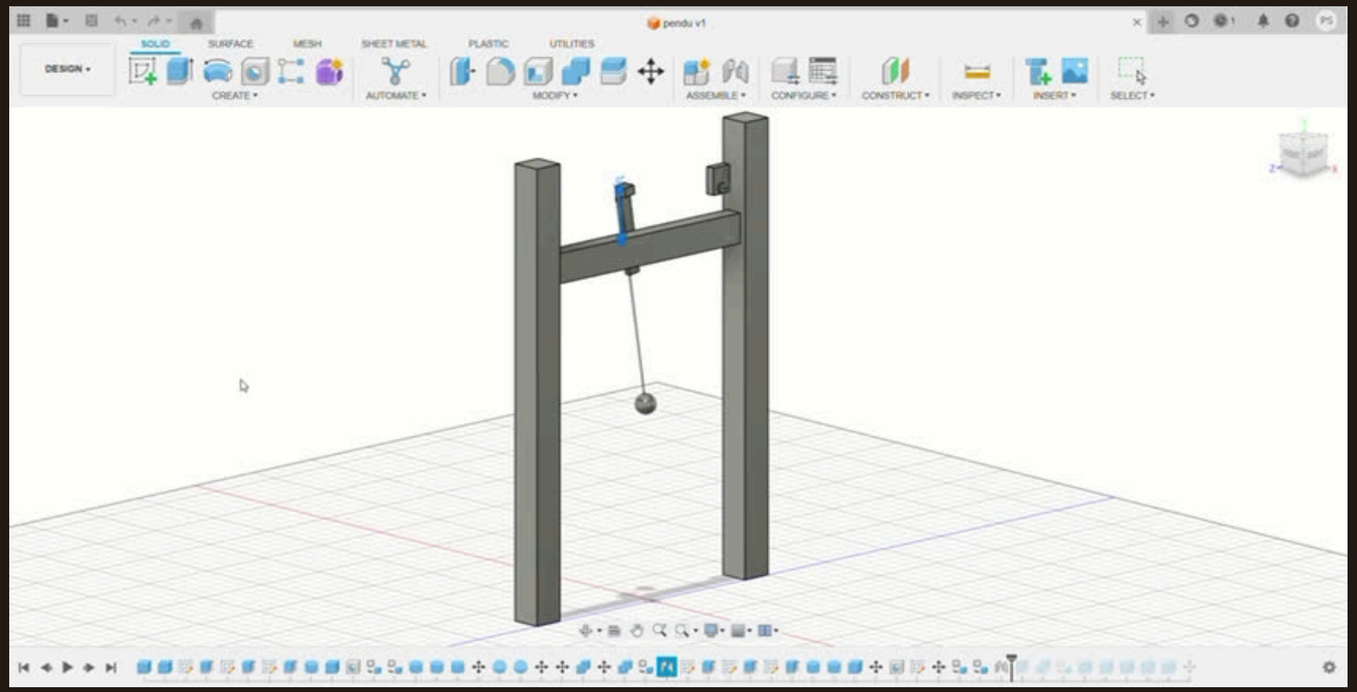

Drawbacks to handle:

1) The flap used with the servo motor should be in the correct position to give good amount of jerk to the wooden rod.

3) Enough width of the wooden stand for complete movement of pendulum

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MODEL

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EXECUTION

```
Rotate on
Oscillations done!
g_total_avg: 7.74
g_total_avg: 9.67
g_total_avg: 9.70
g_total_avg: 9.77
g_total_avg: 9.79
```

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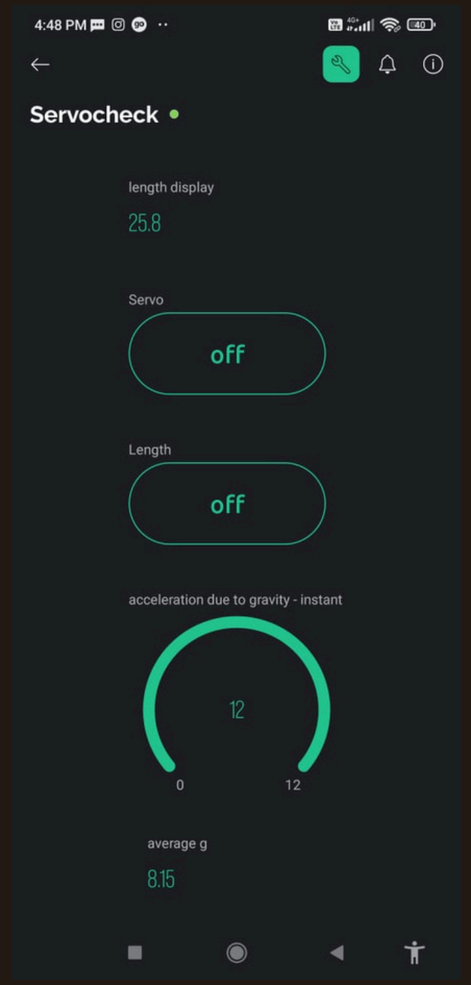
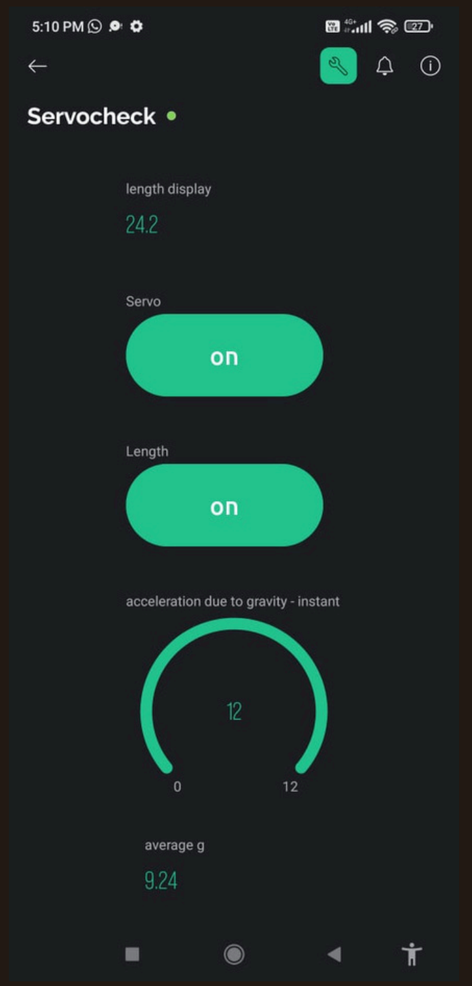
Max length - 25.8cm



Max length - 24.2cm



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EXPLANATION

- In the hardware model, a servo motor is employed to initiate the motion of the pendulum and set it in motion.
- Here, the hardware consists of the shown wooden model.
- As we initiate the motion using servo motor, we can observe the 3d printed segment connected to motor helps to provide jerk to the wooden rod.
- This rod further provides jerk to the pendulum string and causes oscillations.
- After a certain amount of time, when oscillations become smooth we will stop servo motor and measure the time period with the help of IR sensor.
- This infrared (IR) sensor is strategically positioned at the midpoint directly beneath the pendulum's ball to recognise when it reaches the equilibrium position and when it deviates from it.
- Further with this time period, we will determine the value of acceleration due to gravity

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SOFTWARE

Code to calculate ‘g’ value using ir sensor and servo motor along with length change using Blynk

```
#define BLYNK_TEMPLATE_ID           "TMPL3Pm2rInpo"
#define BLYNK_TEMPLATE_NAME         "Servocheck"
#define BLYNK_AUTH_TOKEN            "GxaHOjnLK4G2liYeK_Hw1aow_8XAj_ox"

#define BLYNK_PRINT Serial


#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <Servo.h>

char ssid[] = "Mt.";
char pass[] = "vava@2026";

Servo servo1;
Servo servo2;
unsigned long startTime = 0;
const int irPin = D1;
bool isIrOn = false;
unsigned long pretime;
unsigned long currtime;
unsigned long timePeriod;
boolean flag = true;
float g;
float l;
float g_avg = 0;
unsigned int count = 0;
float g_total = 0;
unsigned int g_count = 0;
```

- Here we are initializing the variables for servo, ir sensor , time period and gravity calculations.
- We are also introducing Blynk Credentials such as Token Id, Template name and Authentication token
- Also we are connecting to the wifi using mobile phone’s hotspot

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SOFTWARE

Code to calculate ‘g’ value using ir sensor and servo motor along with length change using Blynk

```
BLYNK_WRITE(V0)
{
  int buttonState = param.asInt();
  if (buttonState == 1) {
    startTime = millis();
    Serial.println("Rotate on");
    while(millis() - startTime < 15000)
    {
      servo1.write(199);
      delay(1500);
      servo1.write(0);
      delay(1500);
    }
    Serial.println("Oscillations done!");
  }
  else {
    // Turn the servo off
    servo1.write(0);
    Serial.println("Rotate off");

  }
}
```

- Here we will be initiating the servo for actuating the motion of pendulum bob
- Also this motion is getting actuated using Blynk app with pin V0
- The servo will be in motion for 15s which is appropriate to get smooth oscillations of the pendulum bob

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SOFTWARE

Code to calculate ‘g’ value using ir sensor and servo motor along with length change using Blynk

```
BLYNK_WRITE(V1)
{
  isIrOn = param.asInt();

  Serial.println("Changing");

  if(isIrOn)
  {
    servo2.write(0);
  }
  else
  {
    servo2.write(199);
  }
}
```

- Here we will be chenging the length of pendulum bob
- For this we will be using V1 pin in Blynk app
- As pin is ON, we will shorten the length, while when the pin is turned OFF, the length will increase
- The value of ‘g’ will change according to this length, for increment in length, there will be increase in ‘g’ value while with decrease in length, ‘g’ value will decrease

$$T = 2*\pi\sqrt{\frac{L}{g}}$$

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SOFTWARE

Code to calculate ‘g’ value using ir sensor and servo motor along with length change using Blynk

```
void setup()
{


  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);

  servo1.attach(2);  // Attach servo to GPIO pin D4
  servo1.write(0);   // Rotate servo to 0 degrees initially

  servo2.attach(0);  // Attach servo to GPIO pin D4
  servo2.write(0);

  delay(2000);      // Wait for 2 seconds after setup
  startTime = millis(); // Record the start time
  Serial.begin(9600);
  pinMode(irPin, INPUT);
  pretime = micros();
}
```

- Here in ‘void setup’, Blynk connection is initializing
- Then we are attaching servo motors to their respective GPIO pins
- The motor for actuation is connected to GPIO pin D4 and the one for length change is connected to GPIO pin D3
- Then we are also assigning startTime to record the start of the time
- Also the pinMode is being setup for irSensor using GPIO pin D1

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Code to calculate ‘g’ value using ir sensor and servo motor along with length change using Blynk

- In the 'void loop' function, we are ready to measure the time period and compute the 'g' value using it. TimePeriod is calculated by taking the difference between the current time and the previous time. Here, we use a boolean variable 'flag' which is initialized to TRUE. If the pendulum bob is directly above the IR sensor, the flag will be true.

- Since we are computing for a complete oscillation, once the pendulum is detected, 'flag' will become FALSE, and at this time, the time difference won't be calculated. Then the flag will be turned to TRUE again.

- Eventually, when there is a final detection of the bob, leading to one complete oscillation, this will compute the final time instant, and we will have the time period of oscillation.

- We will use a 'count' variable which will get incremented up to 10. This is done to avoid the initial 10 values obtained from the IR sensor which are generally not steady.

- After this, we will take 5 consecutive values and compute the average value to display on the Blynk app.

$$T = 2*pi\ sqrt{\frac{L}{g}}$$

```
void loop()
{
  Blynk.run();
  if (digitalRead(irPin) == LOW) { // Changed to LOW for active low sensor
   if (flag == true) {
     currtime = millis();
     timePeriod = currtime - pretime;
     pretime = currtime;
     flag = !flag;

     double period_sq = timePeriod * timePeriod;
     g = ((4 * 3.141 * 3.141 * 24) / period_sq) * 10000;

     // new block
     count++;
     if(count>=10)
     {
       g_count++;
       g_total = g_total + g;
       if(g_count == 5)
       {
         // Serial.print("g_total_sum: ");
         // Serial.println(g_total);
         g_avg = g_total / 5;
         if(g_avg > 7 && g_avg <12)
         {
           Serial.print("g_total_avg: ");
           Serial.println(g_avg);
           Blynk.virtualWrite(V2, g_avg);
         }

         g_count = 0;
         g_total = 0;
       }
     }

     delay(100);
   } else {
     flag = !flag;
     delay(100);
   }
  }
}
```

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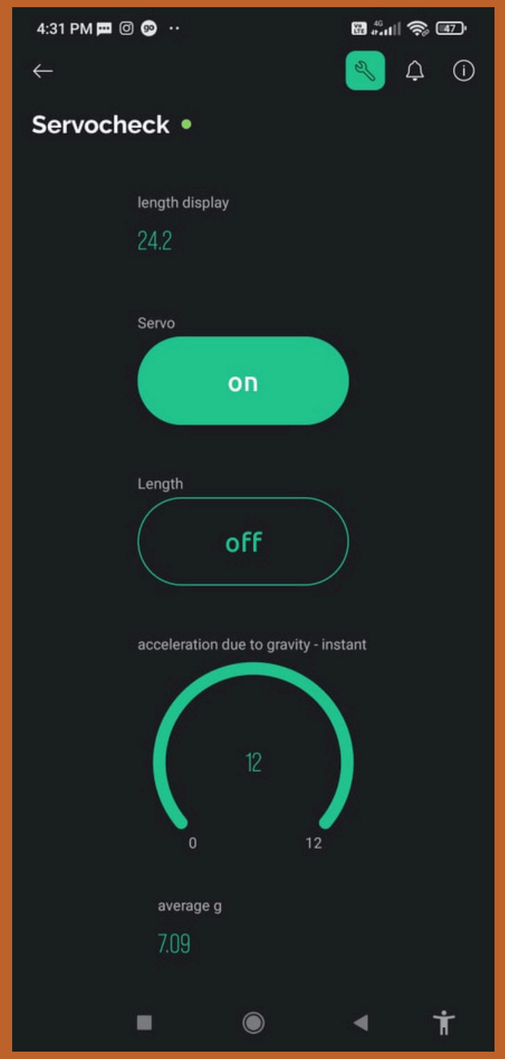
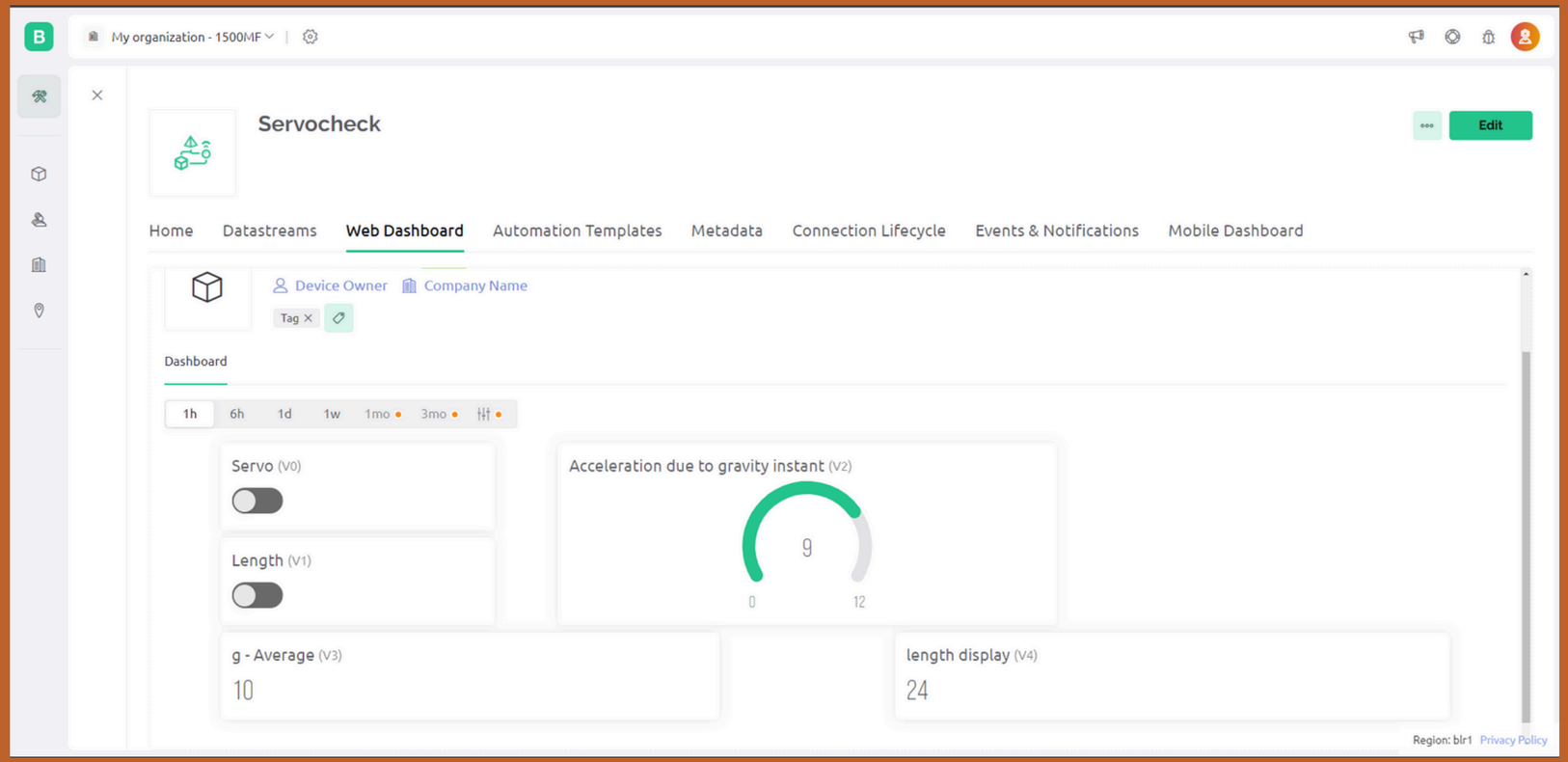
COMMUNICATION PROTOCOL: Blynk IoT





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CHALLENGES FACED

- **Calibration of IR sensor & positioning** - We had to calibrate the IR sensor to fine-tune the sensor's sensitivity and threshold for detecting the pendulum's position accurately.
- **Wrong servo motor** - The servo motor initially given to us had faulty wiring which eventually led to short circuit of our esp32, for the reason we had to change our microcontroller to esp8266
- **Angle movement of servo & mean position adjustment** - We had tough time adjusting the 3d printed flap to servo motor in order to find the mean position when the servo stops
- **Blynk connection with esp -** It was also a challenge to connect esp to Blynk via hotspot as initially the credentials used were not compaible for Blynk Connection

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TIMELINE

- Checkpoint 1 - Approaching the problem statement with rough model
- Checkpoint 2 - Calculation of time period using IR Sensor without complete setup
- Checkpoint 3 - Testing all the components
- Checkpoint 4 - Complete wooden model
- Checkpoint 5 - Adjustment of flap connected to servo with the model
- Checkpoint 5 - Writing the entire code as per the required actuatuion and ‘g’ value calculation
- Checkpoint 6 - Adjustment of length

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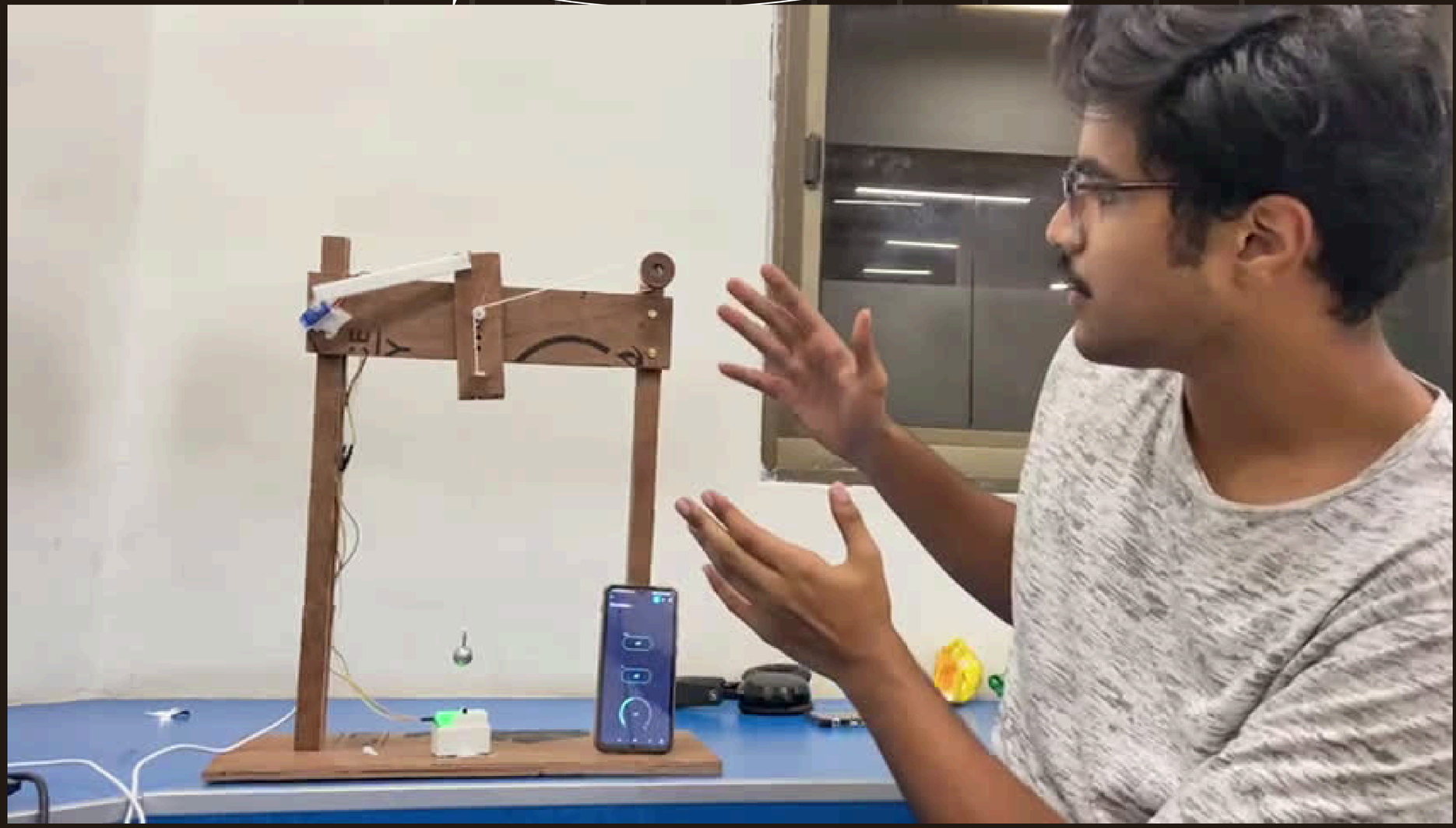
CONCLUSION



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Thank You!

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