Name: Cheung Tsz Chun Noddy

ID: 220171174

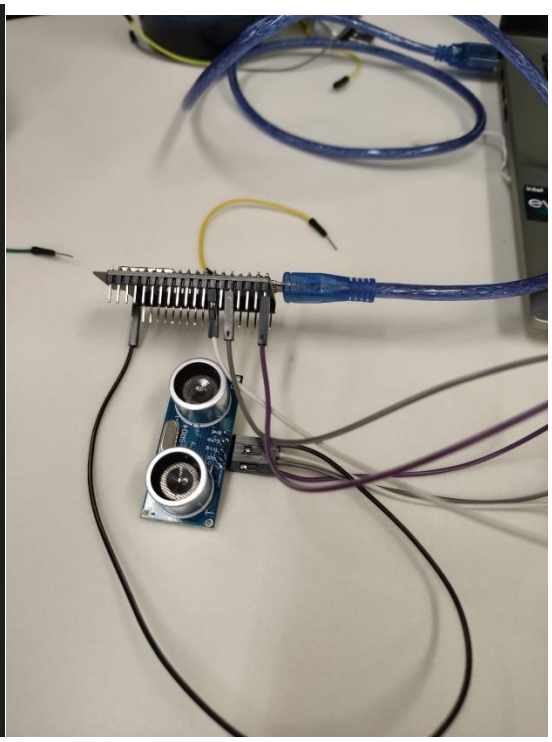
Subject: MBS4544

a)

hc sr04 test > src > main.cpp > loop()

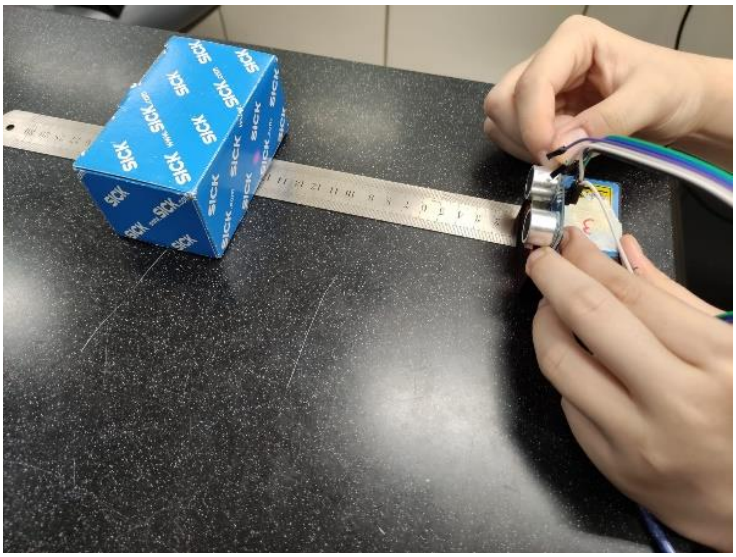
```cpp
#include <Arduino.h>
#include <HCSR04.h>

UltraSonicDistanceSensor distanceSensor(13, 12);  // Initialize sensor that uses digital pins 13 and 12.

void setup () {
    Serial.begin(9600);  // We initialize serial connection so that we could print values from sensor.
}

void loop () {
    // Every 1 second, do a measurement using the sensor and print the distance in centimeters.
    double distance = distanceSensor.measureDistanceCm();
    Serial.print(F("°C - Distance: "));
    Serial.print(distance);
    Serial.println(F("cm"));
    delay(1000);
}
```

```
°C - Distance: 17.54cm
°C - Distance: 21.66cm
°C - Distance: 59.84cm
°C - Distance: 15.93cm
°C - Distance: 16.24cm
°C - Distance: 21.95cm
°C - Distance: 17.54cm
°C - Distance: 200.40cm
°C - Distance: 201.80cm
°C - Distance: 200.91cm
°C - Distance: 29.12cm
```



b)

```
Distance: 34.52cm
Distance: 34.27cm
Distance: 34.01cm
Distance: 34.01cm
Distance: 31.40cm
Distance: 14.92cm
Distance: 14.61cm
Distance: 15.25cm
Distance: 15.56cm
Distance: 15.25cm
Distance: 14.27cm
Distance: 13.94cm
Distance: 13.94cm
Distance: 15.23cm
Distance: 14.92cm
Distance: 14.92cm
Distance: 14.61cm
Distance: 14.59cm
Distance: 14.59cm
Distance: 15.25cm
Distance: 14.59cm
Distance: 14.59cm
Distance: 14.92cm
Distance: 15.25cm
Distance: 15.25cm
Distance: 15.25cm
```



T53 > src > main.cpp > loop()

```cpp
#include <Arduino.h>
int readPin = 25;
float scale = 0.0f;
float minimum = 15.0f;
float maximum = 60.0f;
float adc_max = 4096.0f;
double distance = 0;

void setup () {
    Serial.begin(9600);  // We initialize serial connection so that we could print values from sensor.
}

void loop () {
    // Every 1 second, do a measurement using the sensor and print the distance in centimeters.
    float x = analogRead(readPin);
    scale = (float)(((maximum - minimum) / adc_max));
    distance = (float) scale * x + minimum;

    Serial.print(F("Distance: "));
    Serial.print(distance);
    Serial.println(F("cm"));
    // Serial.println(x);
    delay(1000);
}
```

C)

hc sr04 test > src > main.cpp > loop()

```cpp
#include <Arduino.h>
#include <HCSR04.h>

int readPin = 25;
float scale = 0.0f;
float minimum = 15.0f;
float maximum = 60.0f;
float adc_max = 4095.0f;
float distance = 0.0f;
float offset = 0.0f;

UltraSonicDistanceSensor distanceSensor(13, 12);  // Initialize sensor that uses digital pins 13 and 12.

void setup() {
  Serial.begin(9600);  // We initialize serial connection so that we could print values from sensor.
}

void loop() {
  // Measure distance using the analog sensor
  float x = analogRead(readPin);
  scale = (float)(((maximum - minimum) / adc_max));
  distance = (float) (scale * x + minimum - offset);

  Serial.print(F("Analog Distance: "));
  if (distance <= minimum){
    Serial.print("<=");
  }
 else if(distance >= maximum){
    Serial.print(">=");
 }
    Serial.print(distance);

  Serial.println(F("cm"));

  // Measure distance using the ultrasonic sensor
  double ultrasonicDistance = distanceSensor.measureDistanceCm();

  Serial.print(F("Ultrasonic Distance: "));
  Serial.print(ultrasonicDistance);
```

```cpp
  Serial.println(F("cm"));

  delay(1000);
}
```

D)Fill the table. (Total: 10%)

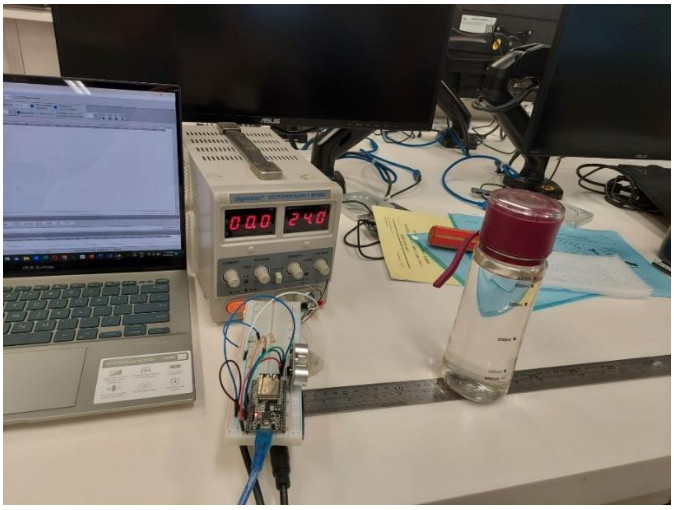
	Ultrasonic (HC-SR04)	Laser (DT35)
Valid measuring range (mm)	20 ~ 4000	50-12,000
Accuracy (mm)	±3	±10
Frequency (Hz)	40	Switching frequency: 166 Hz/50 Hz/25 Hz/12 Hz/3 Hz
Around price (HKD)	35.00	5,221.12

5) i),ii),iii)

Items: transparent bottle with water

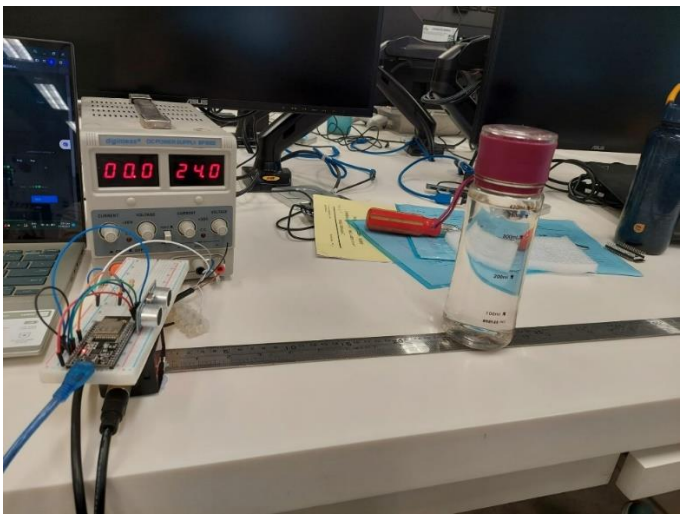
15cm

```
1    5    10    15    20    25    30
Analog Distance: 21.08cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.19cm
Ultrasonic Distance: 16.84cm
Analog Distance: 21.15cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.16cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.15cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.19cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.15cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.15cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.14cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.10cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.22cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.15cm
Ultrasonic Distance: 15.56cm
Analog Distance: 21.15cm
Ultrasonic Distance: 15.56cm
```



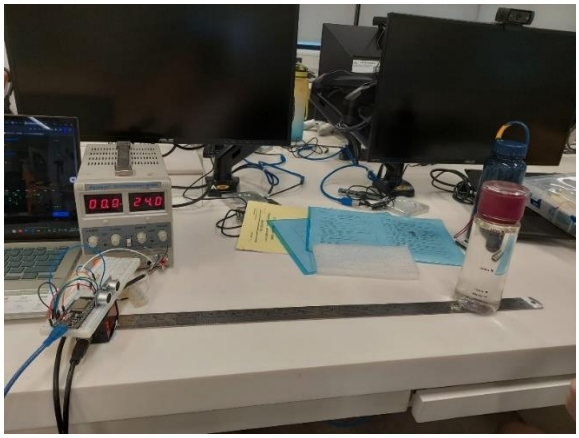
25cm

```
Analog Distance: 33.65cm
Ultrasonic Distance: 26.57cm
Analog Distance: 33.66cm
Ultrasonic Distance: 15.56cm
Analog Distance: 31.18cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.14cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.16cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.14cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.15cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.13cm
Ultrasonic Distance: 26.26cm
Analog Distance: 31.11cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.08cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.19cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.18cm
Ultrasonic Distance: 26.24cm
Analog Distance: 31.19cm
Ultrasonic Distance: 26.24cm
```



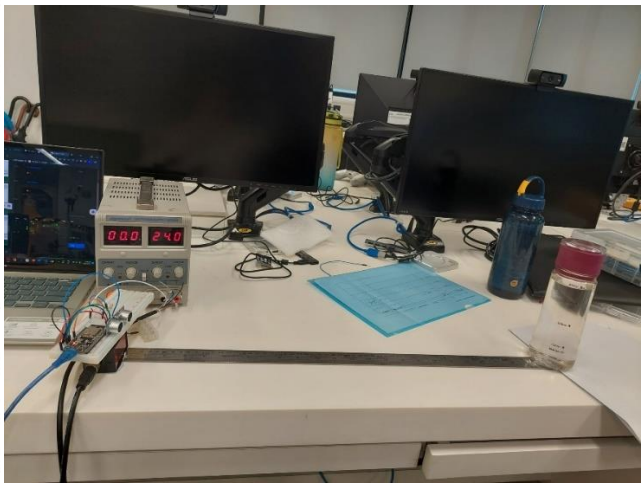
50cm

```
1    5    10    15    20    25    30
Analog Distance: 59.80cm
Ultrasonic Distance: 51.04cm
Analog Distance: 59.31cm
Ultrasonic Distance: 51.02cm
Analog Distance: 58.43cm
Ultrasonic Distance: 51.02cm
Analog Distance: 57.41cm
Ultrasonic Distance: 50.68cm
Analog Distance: 58.76cm
Ultrasonic Distance: 50.68cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 51.02cm
Analog Distance: 57.73cm
Ultrasonic Distance: 50.18cm
Analog Distance: 59.15cm
Ultrasonic Distance: 50.68cm
Analog Distance: 58.60cm
Ultrasonic Distance: 50.68cm
Analog Distance: 59.33cm
Ultrasonic Distance: 50.68cm
Analog Distance: 58.43cm
Ultrasonic Distance: 50.68cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 50.68cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 50.16cm
```



60cm

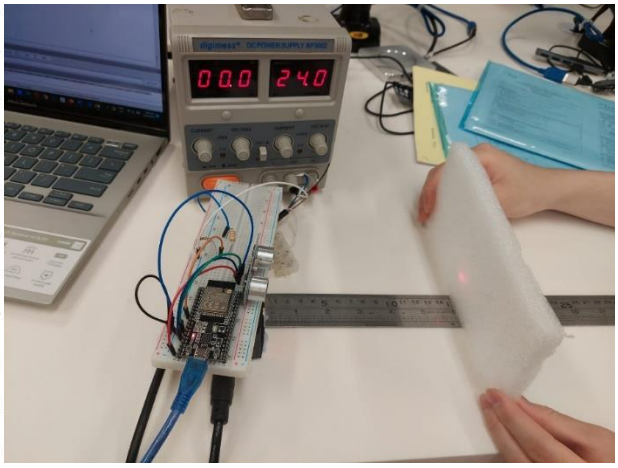
```
1    5    10    15    20    25    30
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 60.21cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.77cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.77cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
```



Tissue(sponge):

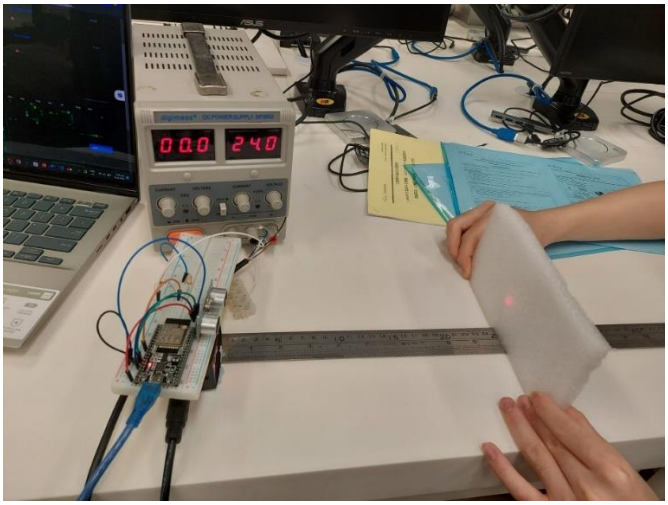
15cm

```
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.92cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.59cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.59cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.92cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.88cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.90cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.88cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.88cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.59cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.59cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.88cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.92cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.90cm
```



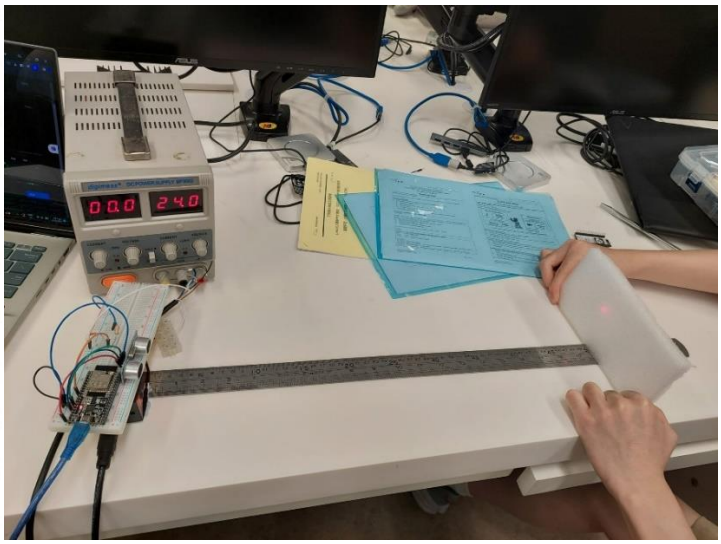
25cm

```
Analog Distance: 24.20cm
Ultrasonic Distance: 26.24cm
Analog Distance: 24.15cm
Ultrasonic Distance: 25.36cm
Analog Distance: 23.99cm
Ultrasonic Distance: 28.78cm
Analog Distance: 24.04cm
Ultrasonic Distance: 25.36cm
Analog Distance: 23.98cm
Ultrasonic Distance: 25.36cm
Analog Distance: 23.87cm
Ultrasonic Distance: 25.36cm
Analog Distance: 23.95cm
Ultrasonic Distance: 25.38cm
Analog Distance: 23.98cm
Ultrasonic Distance: 25.36cm
Analog Distance: 23.91cm
Ultrasonic Distance: 28.78cm
Analog Distance: 23.93cm
Ultrasonic Distance: 26.24cm
Analog Distance: 23.95cm
Ultrasonic Distance: 28.78cm
Analog Distance: 23.95cm
Ultrasonic Distance: 28.76cm
Analog Distance: 23.97cm
Ultrasonic Distance: 26.58cm
```



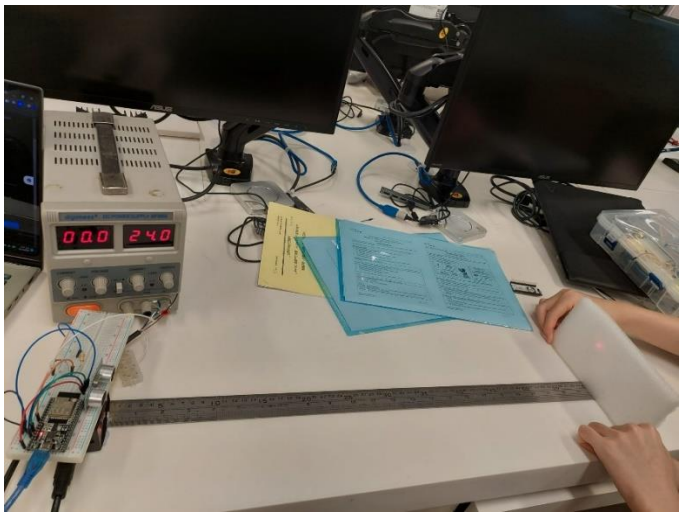
50cm

```
Analog Distance: 59.80cm
Ultrasonic Distance: 51.04cm
Analog Distance: 59.31cm
Ultrasonic Distance: 51.02cm
Analog Distance: 58.43cm
Ultrasonic Distance: 51.02cm
Analog Distance: 57.41cm
Ultrasonic Distance: 50.68cm
Analog Distance: 58.76cm
Ultrasonic Distance: 50.68cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 51.02cm
Analog Distance: 57.73cm
Ultrasonic Distance: 50.18cm
Analog Distance: 59.15cm
Ultrasonic Distance: 50.68cm
Analog Distance: 58.60cm
Ultrasonic Distance: 50.68cm
Analog Distance: 59.33cm
Ultrasonic Distance: 50.68cm
Analog Distance: 58.43cm
Ultrasonic Distance: 50.68cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 50.68cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 50.16cm
```



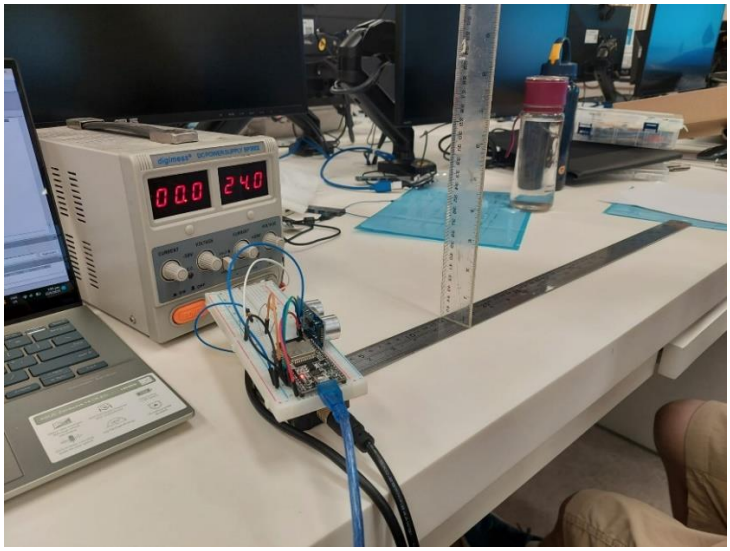
60cm

```
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 60.21cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.77cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.77cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.78cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
```



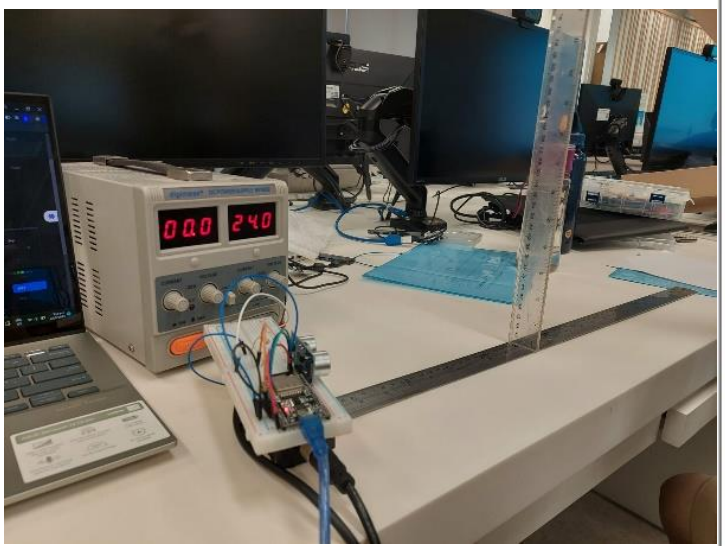
transparent ruler:

15cm



```
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.56cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.56cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 16.19cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.56cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.90cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 16.19cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.23cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.92cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.88cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 15.88cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.58cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.59cm
Analog Distance: <=15.00cm
Ultrasonic Distance: 14.92cm
```

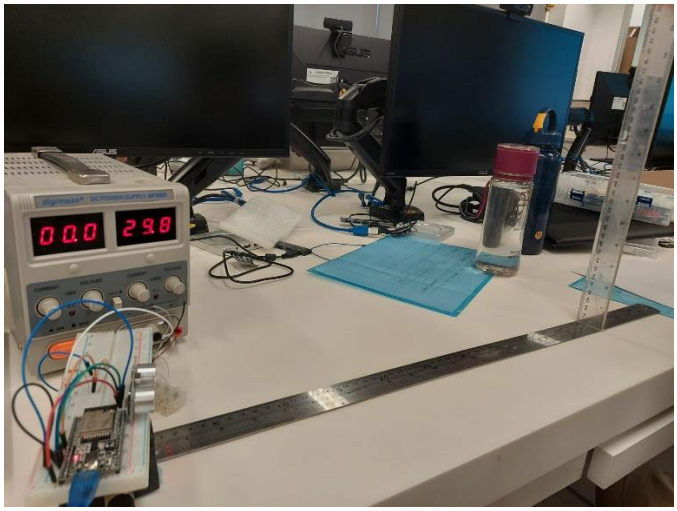
25cm



```
Analog Distance: 23.74cm
Ultrasonic Distance: 23.62cm
Analog Distance: 23.54cm
Ultrasonic Distance: 21.57cm
Analog Distance: 23.46cm
Ultrasonic Distance: 26.58cm
Analog Distance: 23.23cm
Ultrasonic Distance: 28.25cm
Analog Distance: 23.37cm
Ultrasonic Distance: 26.58cm
Analog Distance: 23.36cm
Ultrasonic Distance: 26.60cm
Analog Distance: 23.42cm
Ultrasonic Distance: 27.41cm
Analog Distance: 23.56cm
Ultrasonic Distance: 25.66cm
Analog Distance: 23.58cm
Ultrasonic Distance: 25.36cm
Analog Distance: 23.52cm
Ultrasonic Distance: 27.99cm
Analog Distance: 23.55cm
Ultrasonic Distance: 26.24cm
Analog Distance: 23.49cm
Ultrasonic Distance: 25.36cm
Analog Distance: 23.60cm
Ultrasonic Distance: 27.41cm
```

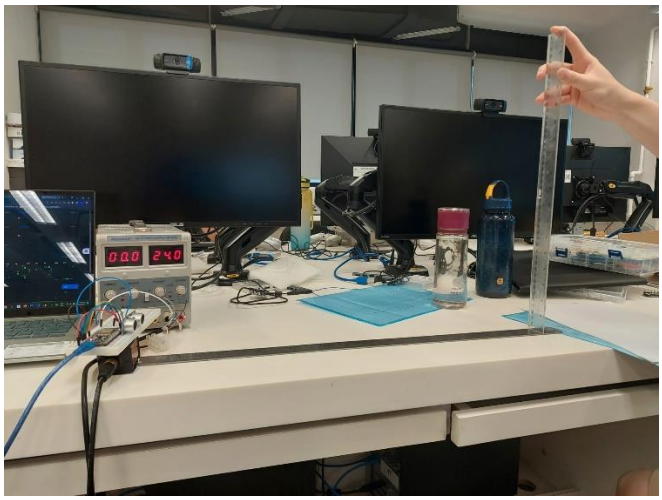
50cm

```
Analog Distance: 40.49cm
Ultrasonic Distance: 46.68cm
Analog Distance: 43.53cm
Ultrasonic Distance: 44.47cm
Analog Distance: 43.97cm
Ultrasonic Distance: 49.99cm
Analog Distance: 44.71cm
Ultrasonic Distance: 49.99cm
Analog Distance: 44.34cm
Ultrasonic Distance: 50.32cm
Analog Distance: 44.68cm
Ultrasonic Distance: 50.32cm
Analog Distance: 44.43cm
Ultrasonic Distance: 49.99cm
Analog Distance: 43.87cm
Ultrasonic Distance: 49.48cm
Analog Distance: 44.69cm
Ultrasonic Distance: 49.48cm
Analog Distance: 45.19cm
Ultrasonic Distance: 49.82cm
Analog Distance: 44.76cm
Ultrasonic Distance: 49.82cm
Analog Distance: 45.27cm
Ultrasonic Distance: 49.48cm
Analog Distance: 44.90cm
Ultrasonic Distance: 49.48cm
```



60cm

```
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.36cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.77cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.63cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 59.20cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 58.24cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 58.22cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 58.21cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 58.22cm
Analog Distance: >=60.00cm
Ultrasonic Distance: 58.22cm
Analog Distance: 47.98cm
Ultrasonic Distance: 58.22cm
Analog Distance: 48.64cm
Ultrasonic Distance: 58.22cm
Analog Distance: 49.19cm
Ultrasonic Distance: 57.80cm
```



iv. “U” stands for ultrasonic sensor, “L” stands for laser sensor. Fill the table. (15%)

	Transparent bottle with water	Tissue(sponge)	Transparent ruler
Error (mm)	U: ±0.65, L: +6.90	U: ±1.30,L: ±1.03	U: -0.695 ,L: -3.45
Stability and Performance (description)	Ultrasonic sensor (“U”): Error ±0.65cm Better stability (smaller error margin) Higher accuracy Laser sensor (“L”): Error ±6.90cm Lower stability (larger error margin) Lower accuracy Laser performance can be affected by transparency and refection issues	Ultrasonic sensor (“U”): Error ±0.65cm Lower stability (larger error margin) Lower accuracy Laser sensor (“L”): Error ±6.90cm Better stability (smaller error margin) Higher accuracy Ultrasonic sensor performance can be affected by the sponge material, and it may absorb some sounds	Ultrasonic sensor (“U”): Error -0.695cm Better stability (smaller error margin) Higher accuracy Laser sensor (“L”): Error -3.45cm Lower stability (larger error margin) Lower accuracy Laser performance can be affected by transparency of the ruler

F) Give a suitable situation / application of each sensor and why. (Total: 10%)

Ultrasonic HC-SR04 Sensor:

- Used in robotics for obstacle detection and avoidance.
- Example: In a robot vacuum cleaner, it helps the device navigate around a room without bumping into furniture or walls.
- It sends out ultrasonic waves that bounce back when they hit an object. The time taken for the waves to return helps calculate the distance to the object.
- Inexpensive, reliable performance

Laser DT35 Sensor:

- Used for safe presence monitoring in intralogistics.
- Example: In an automated warehouse system, it ensures that the path of an automated guided vehicle (AGV) is clear before it starts moving.
- It uses laser technology to measure the distance to any potential obstacles. If an obstacle is detected within a certain range, the AGV can be programmed to stop or change its path.
- Long range

Choosing between the two sensors:

- Depends on factors such as required range, accuracy, cost, and environmental conditions.
- HC-SR04 is generally cheaper and easier to use, suitable for hobbyist projects and simple applications.
- DT35 offers higher accuracy and longer range, suitable for more demanding industrial applications.