AM5023- PHYSIOLOGICAL MEASUREMENTS AND INSTRUMENTATION LABORATORY

BIOPHOTONICS - LABORATORY REPORT

Submitted by: DINESH KUMAR M

Registration no: AM23M022

DEPARTMENT OF APPLIED MECHANICS & BIOMEDICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

ASSESSMENT OF VARIATION IN SKIN CONDUCTANCE UNDER VARIOUS PHYSIOLOGICAL CONDITIONS

OBJECTIVE

To measure the changes in skin conductance stemming from variations in sweat gland activity induced by diverse external stimuli factors like emotions, stress, temperature, etc.

THEORY

Skin conductance variation, or Galvanic skin response (GSR) or Electrodermal activity (EDA), quantifies the electrical conductance between two points on the skin. Skin conductance changes due to the activity of sweat glands and the resulting moisture content on the skin. Here are some reasons: emotional arousal, stress, physiological arousal, temperature, pain or discomfort, cognitive and mental processes, etc.

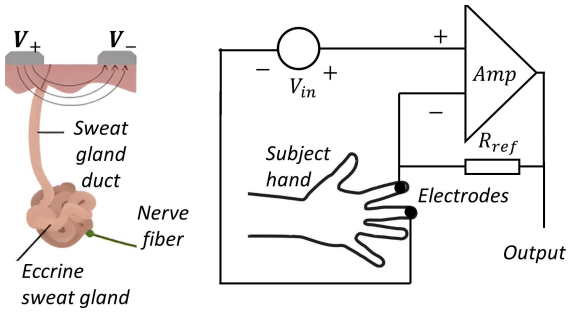


Figure 1: Principle of skin conductance measurement.

EXPERIMENTAL SETUP

The block diagram of the experimental setup is depicted in Figure 2. It contains two electrodes, a GSR amplifier, a Data acquisition system, and a computer with Lab Chart data analysis software. In GSR measurements, electrodes are affixed to the subject's fingers. A consistent, minimal voltage is applied across the electrodes. The resulting current, influenced by skin resistance fluctuations, allows computation of the skin's conductance alterations. These real-time data are then graphically represented using Lab Chart software, enable analysis of skin conductance changes in response to emotional or stressful stimuli.

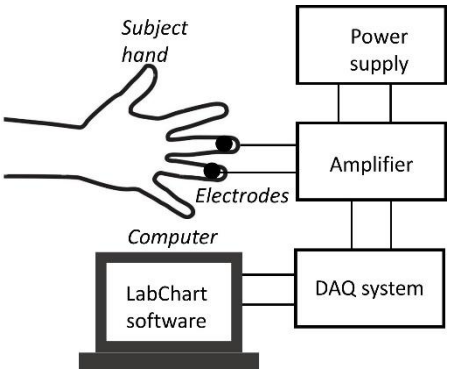


Figure 2: Block diagram for GSR measurement.

GSR signal pattern

The formulas for computing conductance ($G(t)$) and conductance level (CL) are:

$$G(t) = \frac{1}{V_{in}/i_{(t)}}; CL = \int_{t_1}^{t_2} G(t) \qquad (1)$$

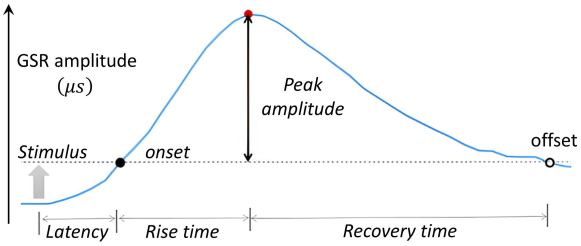


Figure 3: GSR response pattern and metrics.

The typical GSR pattern and its matrices is depicted in Figure 3. Latency Time: Duration between stimulus onset and skin conductance response initiation, indicating the speed of physiological reaction to stimuli. Rise Time: Speed of skin conductance changes from baseline to peak during a response; faster rise times signal rapid physiological reactions. Recovery Time: Speed of skin conductance returning to baseline after a response; shorter times imply efficient emotional arousal regulation.

MATLAB CODE:

```
csvFile = 'C:\Users\DineshKumar\OneDrive\Desktop\E1.csv';
data = csvread(csvFile);
% E1 DATA PLOT
x = data(:, 1);
y = data(:, 2);
scatter(x,y);
xlabel('TIME');
ylabel('GSR AMPLITUDE ');
title('GSR Response pattern E1');
grid on;
```

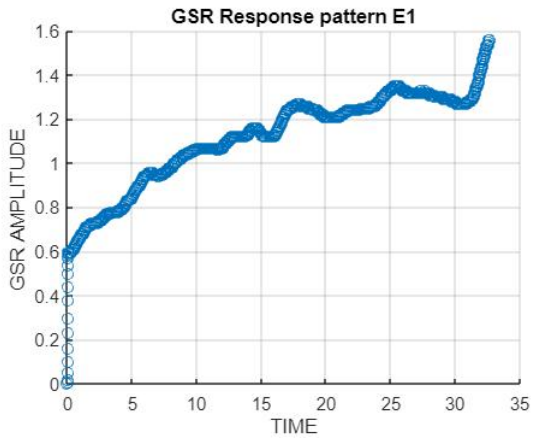
```
%E2 DATA PLOT
a = data(:, 6);
b = data(:, 7);
scatter(a, b);
xlabel('TIME');
ylabel('GSR AMPLITUDE ');
title('GSR Response pattern E2');
grid on;
```

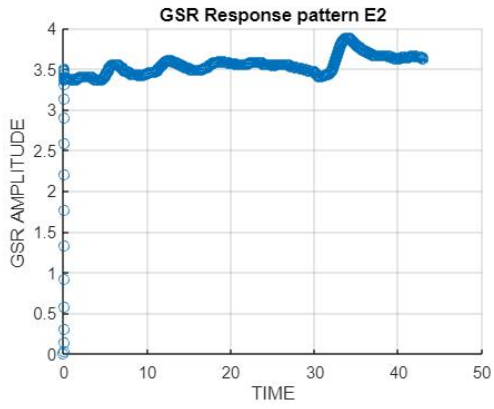
```
c = data(:, 11);
d = data(:, 12);
scatter(c, d);
xlabel('TIME');
ylabel('GSR AMPLITUDE ');
title('GSR Response pattern E3');
grid on;
```

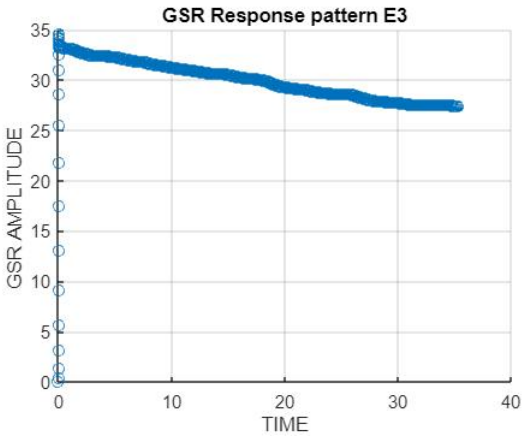
```
e = data(:, 16);
f = data(:, 17);
```

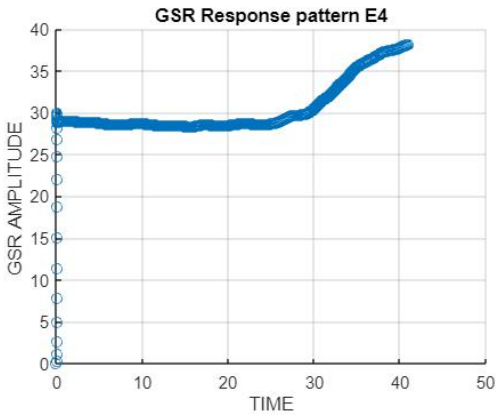
```
scatter(e, f);
xlabel('TIME');
ylabel('GSR AMPLITUDE ');
title('GSR Response pattern E4');
grid on;
```

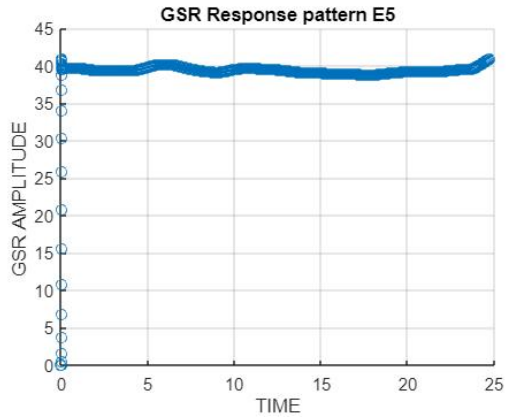
```
g = data(:, 20);
h = data(:, 21);
scatter(g, h);
xlabel('TIME');
ylabel('GSR AMPLITUDE ');
title('GSR Response pattern E5');
grid on;
```











INFERENCE

The study aimed to understand how Galvanic Skin Response (GSR) relates to emotions, cognitive load, habituation, and biofeedback.

OUTCOME

GSR increased with fear and stress, indicating emotional arousal.

GSR correlated with cognitive load, showing its sensitivity to mental effort.

Habituation led to decreased GSR after repeated exposure to the **same** stimulus.

GSR biofeedback was effective for stress management.

CONCLUSION

GSR is a valuable tool for measuring emotional arousal and cognitive load.

Habituation should be considered in GSR experiments.

GSR can assist in stress management through biofeedback.

BLOOD PRESSURE MEASUREMENT USING A PIEZOELECTRIC SENSOR AND ITS APPLICATION

OBJECTIVE

To simulate the blood pressure variations with changes in the vessel diameter and blood flow rate.

THEORY

Blood pressure measurement using a piezoelectric sensor involves a sensor that generates an electric signal in response to pressure. Piezoelectric sensors operate on the principle of the piezoelectric effect, which describes the generation of an electric signal in certain materials (quartz crystals and various ceramics, possess a non-centrosymmetric crystal structure, where the positive and negative charges within the crystal are not symmetrically distributed) when subjected to pressure. The magnitude of the generated electric signal (millivolts to volts) is directly proportional to the applied pressure.

EXPERIMENTAL SETUP

The block diagrams of the experimental setup are depicted in Figure 1 and Figure 2 (Calibration and Testing). It contains a piezoelectric sensor, a bridge amplifier, a data acquisition system, a converging- diverging flow nozzle, a syringe pump, a micro- tubule, a micro-needle, a large diameter tubule, two syringes, and a computer with Lab Chart data analysis software. The piezoelectric pressure sensor undergoes calibration through integration with a sphygmomanometer setup.

The flow nozzle inter- faces one end with the sphygmomanometer and the other with a syringe, while the piezoelectric sensor is affixed to the flow nozzle. This sensor output is channeled into a bridge amplifier for signal amplification. The amplified signal is then routed to Power Lab for data acquisition. Power Lab, linked to a computer via USB, interfaces with Lab Chart for signal visualization.

The syringe is manipulated during calibration to raise manometric pressure to 100 mmHg, and the corresponding voltage alteration is recorded. Simultaneously, the voltage corresponding to 0 mmHg is recorded. These values facilitate unit conversion, enabling data representation in mmHg units on the graph.

Post-calibration, the syringe, now filled with water, is mounted onto a syringe pump. This syringe interfaces with the inlet of a converging-diverging flow-type nozzle. Subsequently, signal acquisition is performed under six distinct scenarios.

The flow rates are maintained at 50ml/hr. and 100 ml/hr. Pressure measurements are taken for three distinct cases over approximately one minute: open-ended, connected to a large diameter tubule, and connected to a micro-tubule.

Steps:

- Lab chart software- new file- channel settings
- Calibrate the sensor at 0 mmHg.
- Make the output voltage to zero if it has some error by applying negative pressure.
- Convert the unit to mmHg.

- **With calibration 0 mV was equal to 0 mmHg and 4.04 mV was equal to 100 mmHg.**

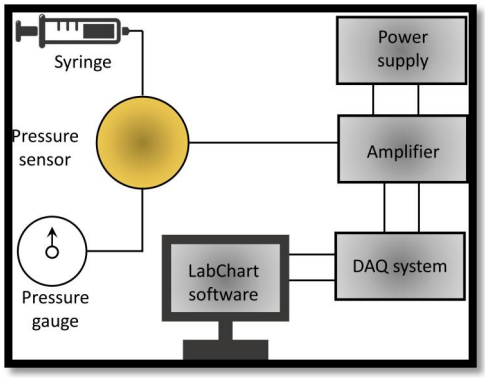


Figure 1: Block diagram for calibration.

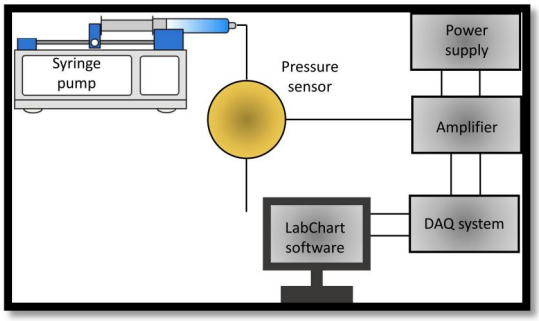


Figure 2: Block diagram for testing .

MATLAB CODE

```
csvFile = "F:\IITM\Physiological measurements lab\piezotrans.xlsx.csv";
data = readmatrix(csvFile);
x = data(:, 2);
y = data(:, 3);
plot(x,y);
xlabel('TIME');
ylabel('PRESSURE (mmHg) ');
title('CASE1');
grid on;
```

```
a = data(:, 6);
b = data(:, 7);
plot(a, b);
xlabel('TIME');
ylabel('PRESSURE (mmHg) ');
title('CASE2');
grid on;
```

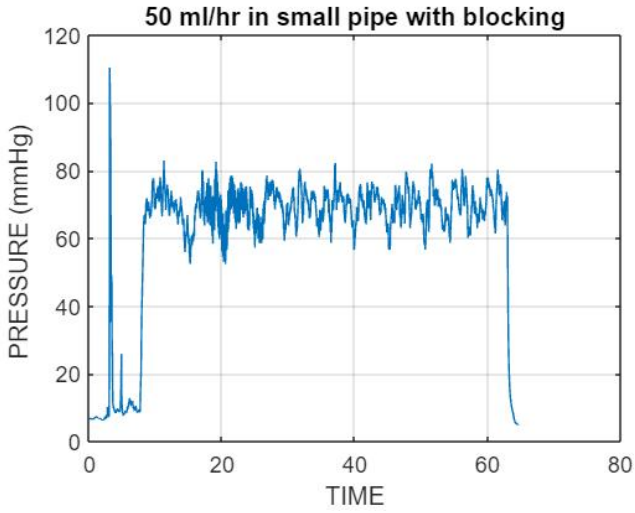
```
c = data(:, 10);
d = data(:, 11);
plot(c, d);
xlabel('TIME');
ylabel('PRESSURE (mmHg) ');
title('CASE3');
grid on;
```

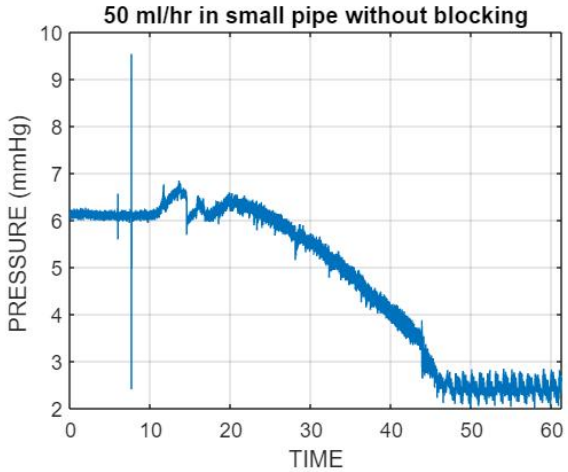
```
e = data(:, 14);
f = data(:, 15);
plot(e, f);
xlabel('TIME');
ylabel('PRESSURE (mmHg) ');
title('CASE4');
grid on;
```

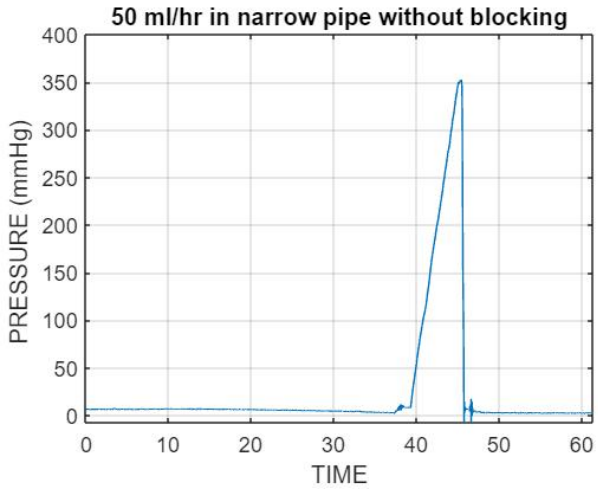
```
g = data(:, 18);
h = data(:, 19);
plot(g, h);
xlabel('TIME');
ylabel('PRESSURE (mmHg) ');
```

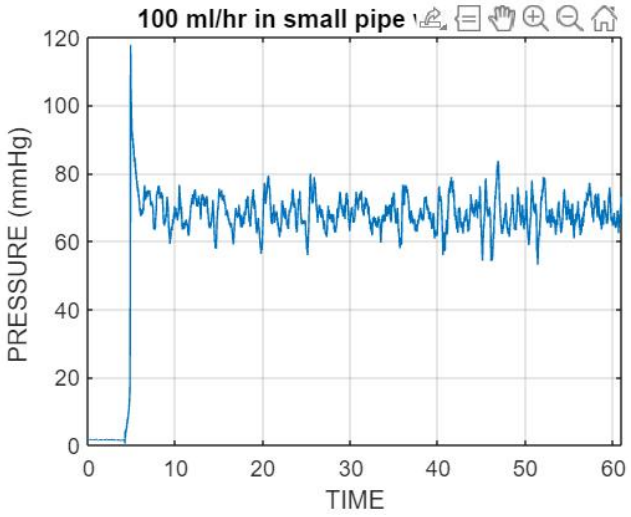
```
title('CASE5');
grid on;
```

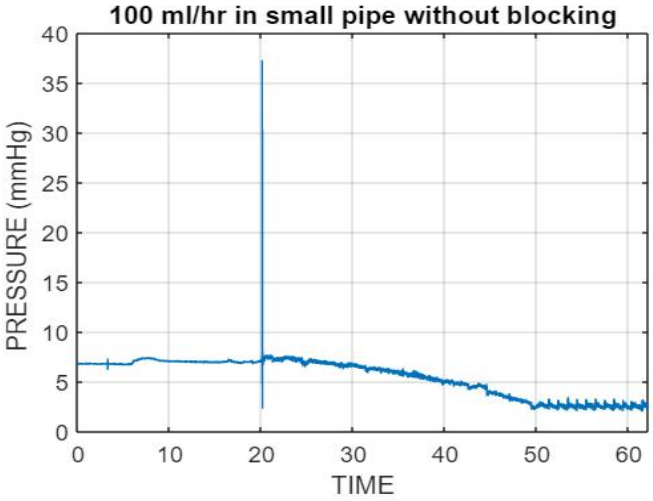
```
o = data(:, 22);
l = data(:, 23);
plot(o, l);
xlabel('TIME');
ylabel('PRESSURE (mmHg) ');
title('CASE6');
grid on;
```

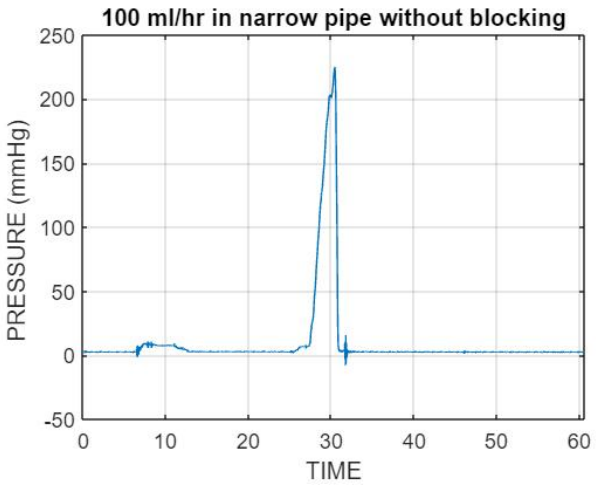





50 ml/hr in narrow pipe without blocking
PRESSURE (mmHg)
TIME
0
50
100
150
200
250
300
350
400
0
10
20
30
40
50
60


100 ml/hr in small pipe
PRESSURE (mmHg)
TIME
0
20
40
60
80
100
120
0
10
20
30
40
50
60


100 ml/hr in small pipe without blocking
PRESSURE (mmHg)
TIME
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60



INFERENCE

When the flow rate increases the pressure increases. When the tube is blocked the pressure tends to increase higher and higher.

OUTCOME

The change in the tubule diameter will cause a pressure change in the waterflowing through the sensor. The pressure changes for the two diameters and the flow rate need to be noted.