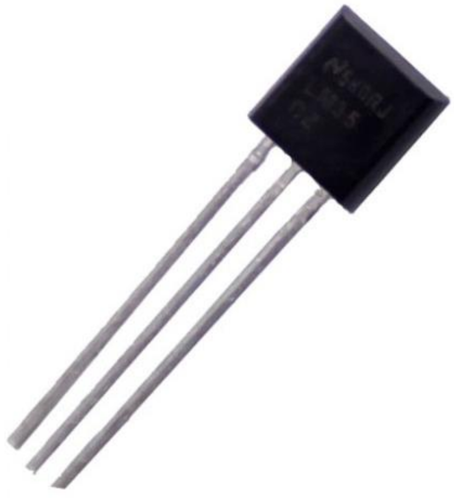
Study on Internal Energy of Fluid Using LM-35 Sensor

PROJECT REPORT



Submitted for the course: PROCESS ENGINEERING THERMODYNAMICS (CHE 1003)

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(SCHOOL OF CHEMICAL ENGINEERING)

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CERTIFICATE

This is to certify that the project work entitled “Study on Internal Energy of Fluid Using LM-35 Sensor” for “Process Engineering Thermodynamics” (CHE1003) is a record of bonafide work done under my supervision. The contents of this Project work, in full or in parts, have neither been taken from any other source nor have been submitted for any other CAL course.

Place: Vellore

Student involved for the project:

SPARSH ARYA- 17BEC0656

Signature of the Faculty: (Dr. BANDARU KIRAN)

ACKNOWLEDGEMENTS

I would like to extend my sincere gratitude to Dr. BANDARU KIRAN for his continued support, inputs, and guidance. Without his vision and constant motivation, the project wouldn’t be possible.

Also, I would like to thank the management of VIT University and to the Dean of SCEME for providing us with this wonderful opportunity to learn new things, and to expand our horizons, through the ample amount of facilities and opportunities available here in VIT University.

TABLE OF CONTENT

ABSTRACT

Thermodynamics is the branch of physics that deals with heat and temperature, and their relation to energy, work, radiation, and properties of matter. Historically, thermodynamics developed out of a desire to increase the efficiency of early steam engines.

Statistical thermodynamics, or statistical mechanics, concerns itself with statistical predictions of the collective motion of particles from their microscopic behavior. Chemical thermodynamics is the study of the interrelation of energy with chemical reactions or with a physical change of state within the confines of the laws of thermodynamics.

The internal energy of a system is the total energy contained within the system. It is the energy necessary to create or prepare the system in any given state, but does not include the kinetic energy of motion of the system as a whole, nor the potential energy of the system as a whole due to external force fields which includes the energy of displacement of the system's surroundings.

Thus, this project deals with implementing the laws of physics and thermodynamics to study the interaction of fluid with external surroundings. The data has been found experimentally using Arduino micro-processer. The data gathered by the sensor is displayed in the laptop and compared with standardized theoretical data.

The project uses C# to code the microprocessor in order to calculate the internal energy. A reference to the LM35 sensor table has also been made.

LITERATURE REVIEW

This section will deal with various properties that affect the rate of heating of cold water when subjected to a constant external temperature. A cold water has low kinetic energy of molecules but the potential energy is large. Thus, the absolute internal energy is a bit tough to calculate. Statistical Probability can be employed to calculate the absolute internal energy.

The processing of absorbing heat from external surroundings to change the temperature of the concerned system is dealt with in detail.

The process of heat transfer can be by:

- Conduction
- Convection
- Radiation

Conduction is process of transfer of heat from source to sink via a material that can conduct heat.

$$\frac{Q}{t} = \frac{\kappa A(T_{hot} - T_{cold})}{d}$$

Convection is process of transfer of heat from source to sink in which particles actually get displaced from their initial positions to transfer heat.

$$q = h\Delta T$$

where

q is the local heat flux density [$W.m^{-2}$]

h is the heat transfer coefficient [$W.m^{-2}.K$]

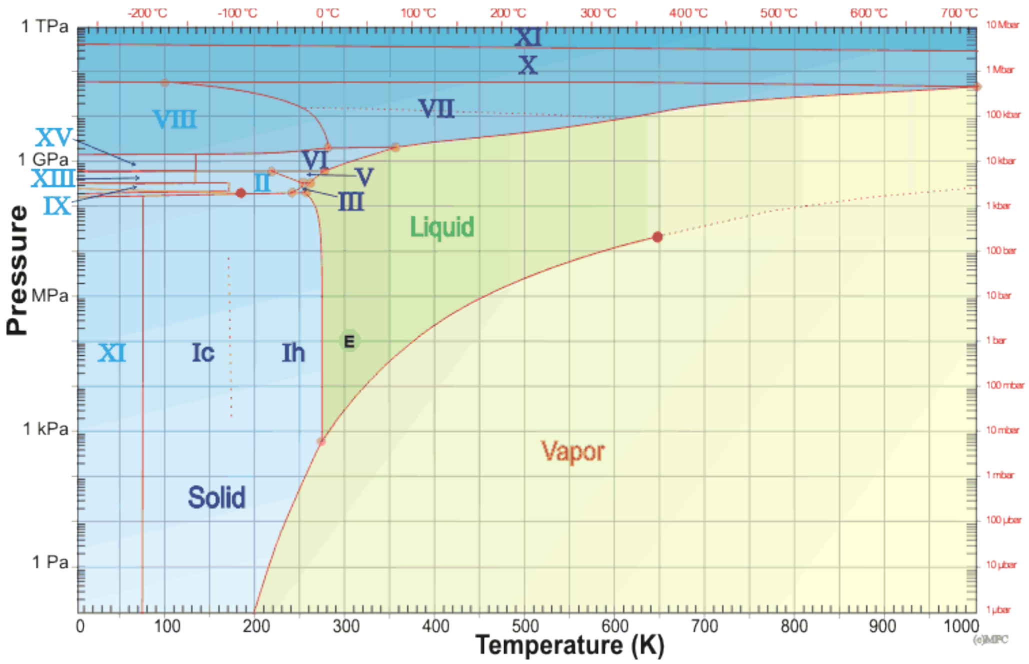
ΔT is the temperature difference [K]

Radiation is a process of transfer of heat that is related electromagnetic spectrum given off by the materials in the system and surroundings.

$$\frac{Q}{t} = A\varepsilon\sigma T^4$$

SP labs experiment for standardized data

Regime for proper working of experiment



Standardized data done at SP labs:

1. Volume of water: $4.80\times10-4$ m34.80×10−4 m3
2. Heat Transfer surface area (ignore wood supporting face): 0.038m2 X 0.038m2
3. Mass of water: 0.48 kg x 0.48 kg
4. Heat capacity of water is 4.2kJ/kg-K

$$\triangle Q=mc(10-27)=(-34.3)kJ$$

Assuming water can transfer heat fast, we get the water temperature change rate,

$$mcdTwaterdt=\dot{Q}mcd(Twater)dt=\dot{Q}$$

Use 10W/m2−K10W/m2−K for air natural convection heat transfer, we get the heat transfer rate,

$$\dot{Q}=hA(Troom-Twater)$$

Thus,

$$mcdTwater=hA(Troom-Twater)dt$$

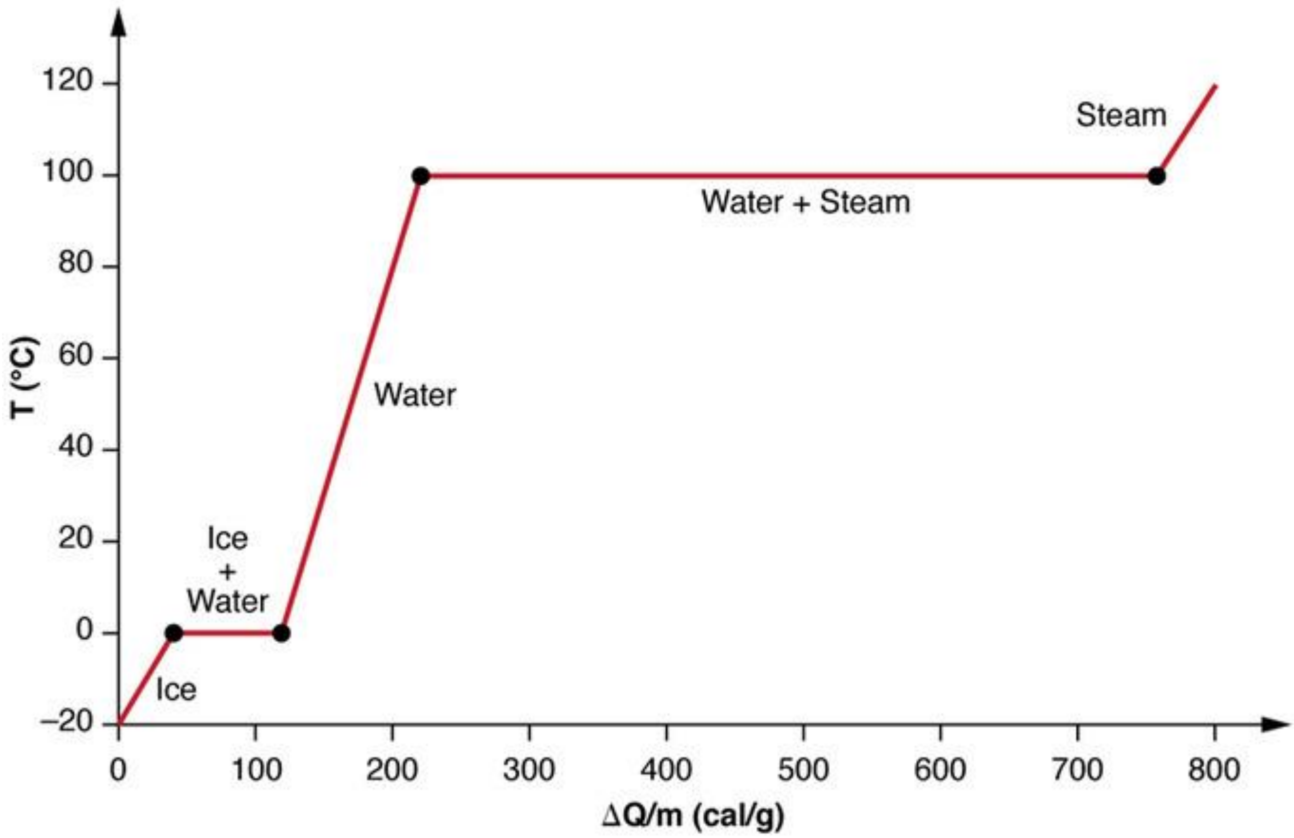
Solving this equation, we get

$Twater=27-17e-hAmct$

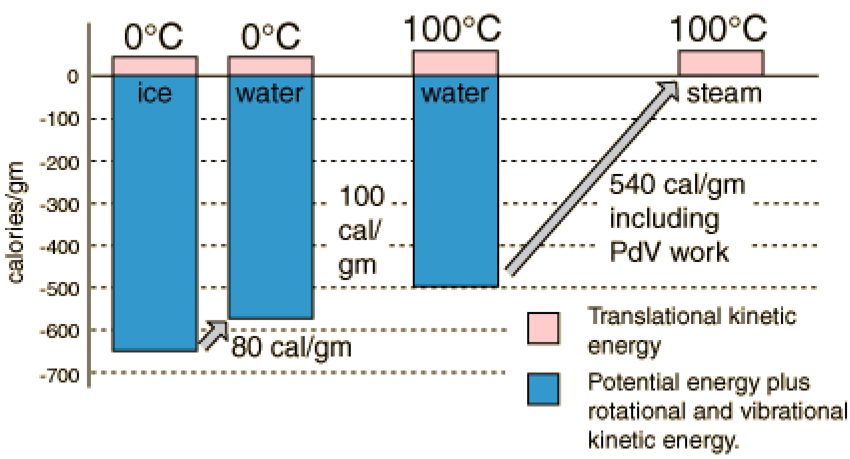
$=27-17e+0.000188t$

.

The main objective of the experiment is to try to derive a plot of temperature verses time and see how much of the content matches with the theoretical values.



The following graph shows the variation of internal energy with fluctuations in temperature.

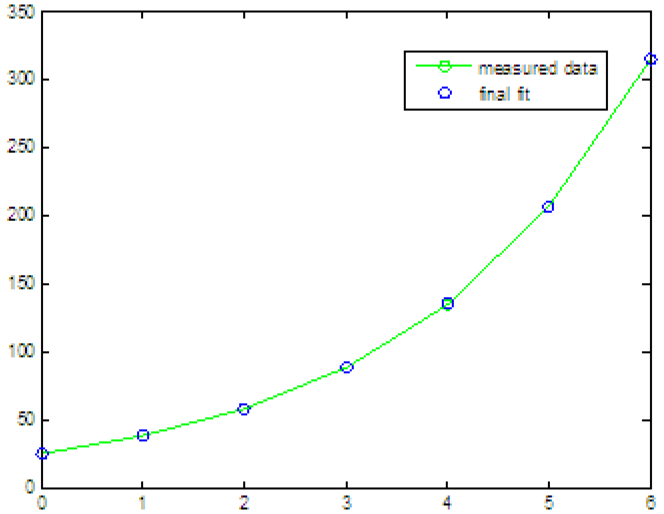


Since the change in internal energy is linearly proportional to the change in temperature,

So, the theoretical value of change in internal energy as a function of time should be a exponentially decaying function d/dt((27−17e+0.000188t)-27)*4.2KJ/mol K* 1=U(t)

delta(U(t)) = d/dt (−17e+0.000188t)*4.2KJ/mol K

=(13.42e+0.000188t) J



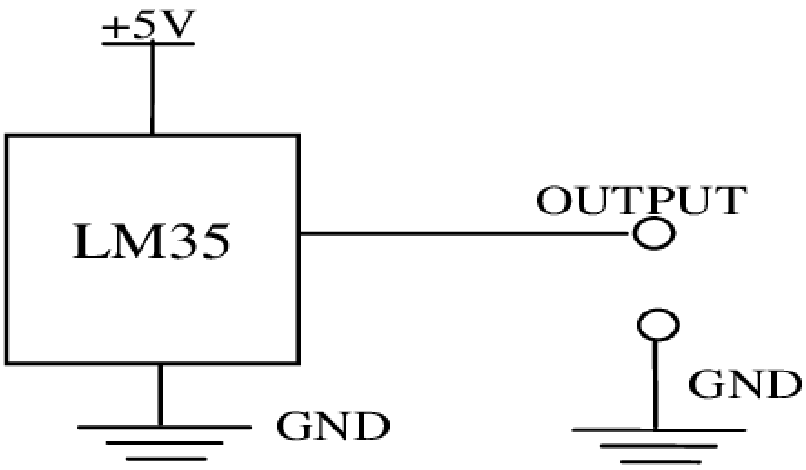
x- axis- Time hours

y-axis- change in internal energy

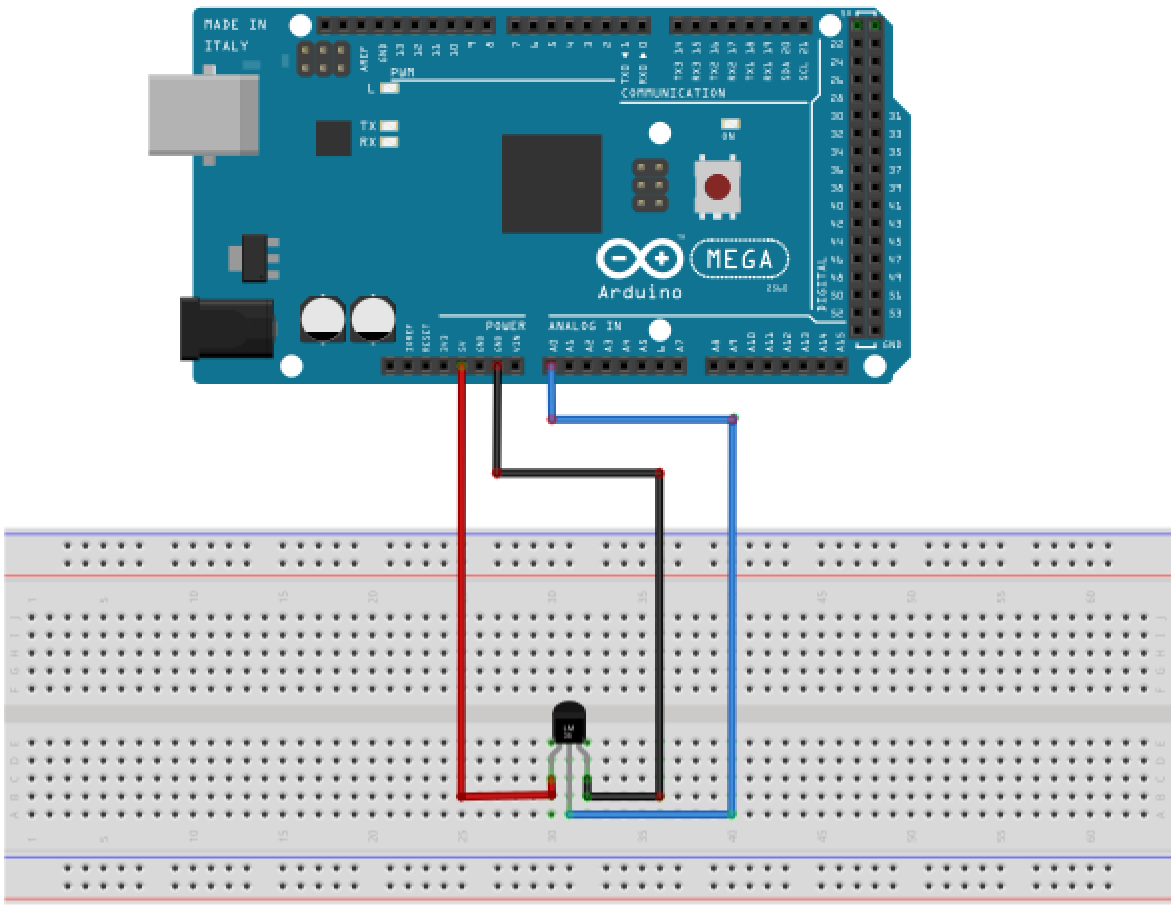
(Expected Outcome from Standard Theoretical measurements)

METHODOLOGY

1. Hardware connections for the sensor are made initially,



2. The circuit is further connected to the Arduino Board.



3. A software code is written in Arduino software in C#

C# code for displaying Sensor Readings on laptop Screen(Serial Monitor)

```
int val;
int tempPin = 1;

void setup()
{
Serial.begin(9600);
}
void loop()
{
val = analogRead(tempPin);
float mv = ( val/1024.0)*5000;
float cel = mv/10;
float farh = (cel*9)/5 + 32;

Serial.print("TEMPERATURE = ");
Serial.print(cel);
Serial.print("*C");
Serial.println();
delay(1000);

/* uncomment this to get temperature in farenhite
Serial.print("TEMPRATURE = ");
Serial.print(farh);
Serial.print("*F");
Serial.println();


*/
}
```

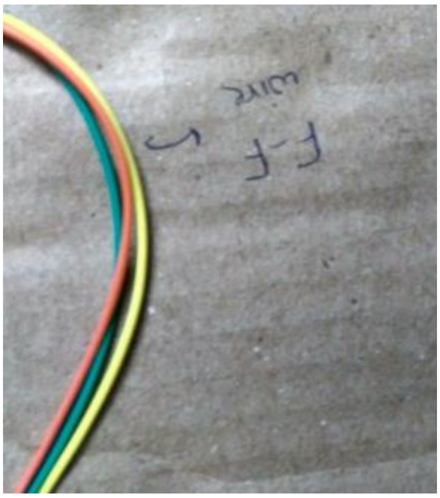
C# Code for printing the change in the internal energy in every 5 seconds

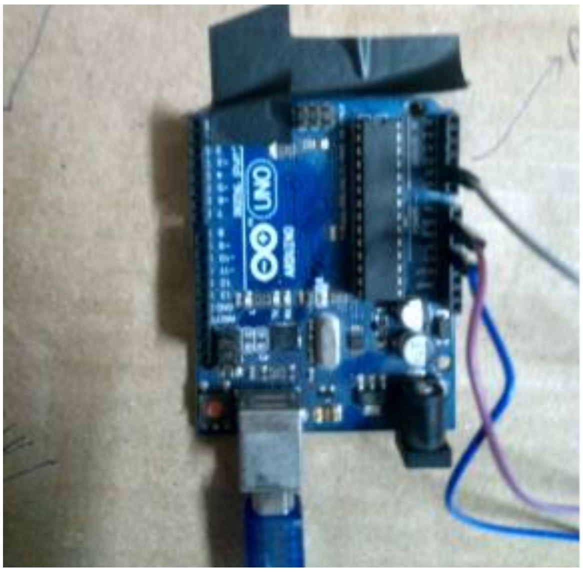
```
const int lm35_pin = A1;  /* LM35 O/P pin */
int vol =0;
int count=0;
int initial=0;
int delt=0;
float temp_adc_val;
float temp_val=0;
float internalE=0;
float check=0;
void setup() {
  Serial.begin(9600);
  Serial.println("Enter your volume of sample taken in ml: ");

  while (Serial.available()==0)
  {                                    //Wait for user input

  }
  vol=Serial.readString().toInt();
}

void loop() {
  temp_adc_val = analogRead(lm35_pin);
  while(temp_adc_val!=0)
  {
    if(count==5)
    {
      initial=temp_adc_val*4.88/10;
    }
    count++;
```

```
/* Read Temperature */
    if(count%5==0)
    {
      delt=(temp_adc_val*4.88/10)-initial;
      check=temp_adc_val*4.88/10;
      internalE=delt*vol*4.18;
      Serial.println("The internal energy change after 5 seconds is ");
      Serial.println(internalE);
    }
  temp_adc_val=0;
  }
  Serial.println(check);
  delay(1000);
}
```

4. The sensor is initially placed in a room of known temperature for caliberation of the instrument.
5. After this a small amount of water is taken in a container and allowed to interact with the ambient temperature. Thus, a plot of temperature vs time is recorded.
6. After this the sensor is placed in a small container with a known volume in ml.
7. This volume is measured upto a good accuracy and given to the computer at runtime.
8. The computer computes the change in internal energy every 5 seconds and displays it onto the screen.
9. This change is recorded.
10. All the results are computed and matched with statistical data as shown in the literary survey.

HARDWARE CONNECTIONS





SOFTWARE CODE

File Edit Sketch Tools Help

ver2.ino

```
void setup()
{
Serial.begin(9600);
}
void loop()
{
val = analogRead(tempPin);
float mv = ( val/1024.0)*5000;
float cel = mv/10;
float farh = (cel*9)/5 + 32;

Serial.print("TEMPERATURE = ");
Serial.print(cel);
Serial.print("*C");
Serial.println();
delay(1000);

/* uncomment this to get temperature in farenhite
Serial.print("TEMPRATURE = ");
Serial.print(farh);
Serial.print("*F");
Serial.println();
```

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```
const int lm35_pin = A1;  /* LM35 O/P pin */
int vol =0;
int count=0;
int initial=0;
int delt=0;
float temp_adc_val;
float temp_val=0;
float internalE=0;
float check=0;
void setup() {
  Serial.begin(9600);
  Serial.println("Enter your volume of sample taken in ml: ");

  while (Serial.available()==0)
  {                                       //Wait for user input

  }
  vol=Serial.readString().toInt();
}

void loop() {
  temp_adc_val = analogRead(lm35_pin);
  while(temp_adc_val!=0)
  {
    if(count==5)


    {
      delt=(temp_adc_val*4.88/10)-initial;
      check=temp_adc_val*4.88/10;
      internalE=delt*vol*4.18;
      Serial.println("The internal energy change after 5 seconds is ");
      Serial.println(internalE);
    }
  temp_adc_val=0;
  }
  Serial.println(check);
  delay(1000);
}
```

RESULTS

Temperature Vs time

COM5 (Arduino/Genuino Uno)

```
TEMPERATURE = 14.79*C
TEMPERATURE = 14.79*C
TEMPERATURE = 15.27*C
TEMPERATURE = 14.79*C
TEMPERATURE = 15.27*C
TEMPERATURE = 14.79*C
TEMPERATURE = 14.79*C
TEMPERATURE = 15.27*C
TEMPERATURE = 14.79*C
TEMPERATURE = 14.79*C
TEMPERATURE = 15.27*C
TEMPERATURE = 15.27*C
TEMPERATURE = 15.27*C
TEMPERATURE = 15.27*C
TEMPERATURE = 15.27*C
TEMPERATURE = 15.76*C
TEMPERATURE = 15.76*C
TEMPERATURE = 15.76*C
TEMPERATURE = 15.76*C
TEMPERATURE = 15.76*C
```

COM5 (Arduino/Genuino Uno)

```
TEMPERATURE = 16.79*C
TEMPERATURE = 16.79*C
TEMPERATURE = 17.27*C
TEMPERATURE = 16.79*C
TEMPERATURE = 16.79*C
TEMPERATURE = 16.79*C
TEMPERATURE = 16.79*C
TEMPERATURE = 17.27*C
TEMPERATURE = 17.27*C
TEMPERATURE = 17.27*C
TEMPERATURE = 17.76*C
TEMPERATURE = 17.27*C
TEMPERATURE = 17.76*C
TEMPERATURE = 17.76*C
TEMPERATURE = 17.76*C
```

COM5 (Arduino/Genuino Uno)

```
TEMPERATURE = 19.27*C
TEMPERATURE = 18.79*C
TEMPERATURE = 18.79*C
TEMPERATURE = 19.27*C
TEMPERATURE = 19.27*C
TEMPERATURE = 19.27*C
TEMPERATURE = 19.27*C
TEMPERATURE = 19.27*C
TEMPERATURE = 19.27*C
TEMPERATURE = 19.76*C
TEMPERATURE = 19.76*C
TEMPERATURE = 19.76*C
TEMPERATURE = 19.76*C
```

COM5 (Arduino/Genuino Uno)

```
TEMPERATURE = 20.79*C
TEMPERATURE = 20.79*C
TEMPERATURE = 20.79*C
TEMPERATURE = 20.79*C
TEMPERATURE = 20.79*C
TEMPERATURE = 21.27*C
TEMPERATURE = 21.27*C
TEMPERATURE = 21.27*C
TEMPERATURE = 21.27*C
TEMPERATURE = 21.27*C
TEMPERATURE = 21.27*C
TEMPERATURE = 21.76*C
TEMPERATURE = 21.76*C
```

COM5 (Arduino/Genuino Uno)

```
TEMPERATURE = 23.79*C
TEMPERATURE = 23.79*C
TEMPERATURE = 23.79*C
TEMPERATURE = 23.79*C
TEMPERATURE = 23.79*C
TEMPERATURE = 23.79*C
TEMPERATURE = 24.27*C
TEMPERATURE = 24.27*C
TEMPERATURE = 24.27*C
TEMPERATURE = 24.76*C
TEMPERATURE = 24.27*C
TEMPERATURE = 24.76*C
TEMPERATURE = 24.27*C
TEMPERATURE = 24.76*C
```

COM5 (Arduino/Genuino Uno)

```
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
TEMPERATURE = 26.79*C
```

INTERNAL ENERGY OUTPUT

Without dipping LM35 in cold water

COM5 (Arduino/Genuino Uno)

```
Enter your volume of sample taken in ml:
0.00
0.00
0.00
0.00
The internal energy change after 5 seconds is
606.10
29.28
29.28
29.28
29.28
29.28
The internal energy change after 5 seconds is
0.00
29.28
29.28
29.28
29.28
29.28
The internal energy change after 5 seconds is
0.00
29.28
29.28
29.28
29.28
29.28
```

After dipping LM35 in cold water

COM5 (Arduino/Genuino Uno)

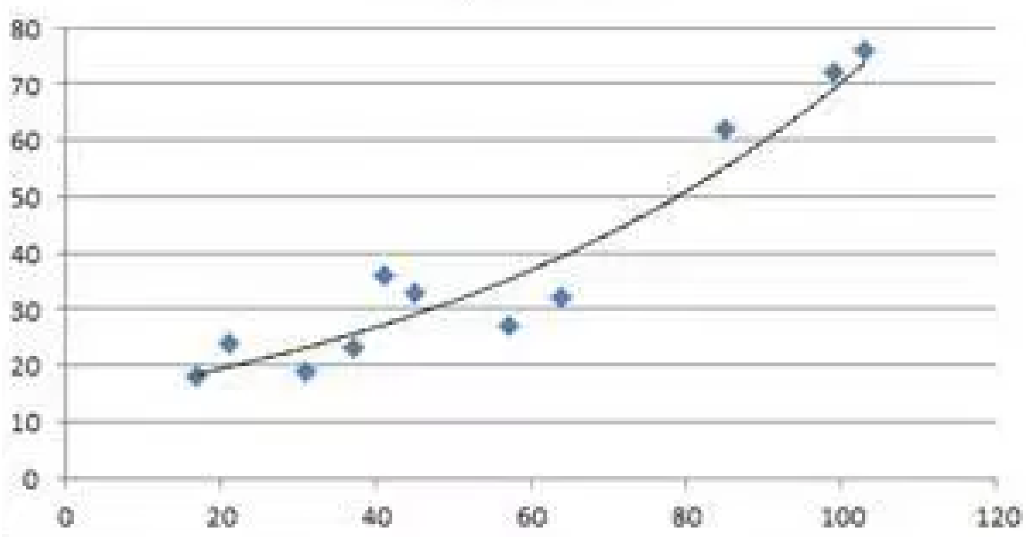
```
Enter your volume of sample taken in ml:
0.00
0.00
0.00
0.00
The internal energy change after 5 seconds is
658.10
19.28
19.28
19.28
19.28
19.28
The internal energy change after 5 seconds is
52.00
19.28
19.28
19.28
19.28
19.28
The internal energy change after 5 seconds is
52.00
19.28
19.28
19.28
19.28
19.28
```

```
The internal energy change after 5 seconds is
72.90
20.26
20.26
20.26
20.26
20.26
The internal energy change after 5 seconds is
72.90
20.74
20.74
20.74
20.74
20.74
The internal energy change after 5 seconds is
72.90
20.74
20.74
20.74
20.74
20.74
The internal energy change after 5 seconds is
93.80
21.23
21.23
21.23
21.23
```

```
The internal energy change after 5 seconds is
102.90
25.26
25.26
25.26
25.26
25.26
The internal energy change after 5 seconds is
102.90
25.74
25.74
25.74
25.74
25.74
The internal energy change after 5 seconds is
102.90
25.74
25.74
25.74
25.74
25.74
```

Using a linear regression model in python

The best fit line for the above values comes out to be an exponential function



x-axis- time in minutes

y axis- change in internal energy

(Observed outcome of the experiment)

Conclusion

The project has been successfully conducted to produce a similar fashion in theoretical data and the data gathered from the experiment.

Both the graphs show an exponential rise in temperature with time.

Thus, general equation for such a system is given by:

T(t)=K1+K2*e^(K3t) degrees Celsius

Theoretical predication time for water to reach room temperature (from graph) =58sec.

Observed time for water to reach room temperature (from graph) =42 sec.

Thus, both the reading from the graph are in close proximity.

Room temperature for ideal conditions in this case is 27 degrees Celsius.

Experiment Succesful.

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