भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
कंदि - ५०२ २८५, संगारेड्डी, तेलंगाना, भारत.
फोन : (०४०) २३०१ ६०३३; फेक्स : (०४०) २३०१ ६००३ /३२

Indian Institute of Technology Hyderabad
Kandi - 502 285, Sangareddy, Telangana, INDIA
Phone: (040) 2301 6033; Fax: (040) 2301 6003 /32

July 14, 2018

TO WHOM SO EVER IT MAY CONCERN

This is to certify that **PIYUSH PALIWAL, BS-MS** student Of "**IISER BHOPAL**" has successfully completed his summer internship on "***Arduino In Science***" under my guidance at **IIT, Hyderabad** from ***May 15, 2018*** to ***July 14,2018.***

He is extremely sincere and hardworking.

I wish him success in all future endeavours.

Sincerely,
Dr. G V V Sharma,
Associate Professor,
Electrical Engineering,
IIT Hyderabad.

सह प्रोफेसर /Associate Professor
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad
Kandi, Sangareddy - 502 285, Telangana, India

Arduino In Science

G V V Sharma*, Piyush Paliwal

Contents

***Abstract*—The objective of this manual is to design experimental setup of science experiments using arduino.**

1.) Experimental setup for determining value of acceleration due to gravity:

OBJECTIVE: finding time of travel by the freely falling object to determine It's acceleration.

COMPONENTS REQUIRED:

- Arduino UNO
- 4 - piezo electric sensors
- 1 - photo interrupter
- 1-LED
- 4-resisters(1k ohm)
- two boxes

CONNECTIONS:

- photo interrupter has three pins: GND, VCC, OUT connect GND to GND of Arduino, VCC to 5V of Arduino, OUT to A4 of Arduino
- we have 4 piezo electric sensors. Connect positive terminal to one end of 1k ohm resister and negative to ground of Arduino. Connect other end of resister to negative of piezo electric sensor. Connect pin A0 of Arduino to positive terminal of piezo-electric sensor.
- Make similar connections for other piezo electric sensors and connect their positive terminals to A1, A2, A3 of Arduino.
- Connect LED: positive to digital pin 13 of Arduino and negative to ground.

PREPARTION OF SETUP:

- In one box fix photo interrupter sensor. On other box fix 4-piezo electric sensors and cover them with card board so that when object will fall on card board piezo sensor can detect it and send signal to Arduino.
- The box having piezo electric sensor is kept at ground and box containing photo interrupter is kept on the top of the table. Make sure that the gap of photo interrupter should of exactly on the piezo sensors so that when object will pass through this gap,it directly falls on piezo sensors.
- After preparation of setup and connections, now connect Arduino to

*The author is with the Department of Electrical Engineering, Indian Institute of Technology, Hyderabad 502285 India e-mail: gadepall@iith.ac.in.

computer and upload the Arduino code which is given after circuit diagram

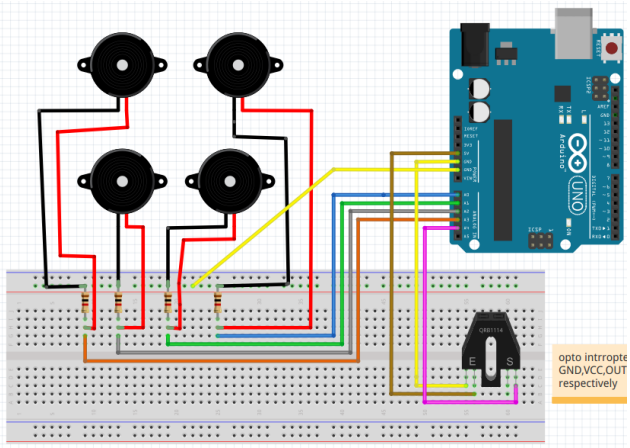
FORMULA:

From equation of motion of particle in straight line,

d=V_0 t+ (1/2) at^2.
for freely falling object with V_0=0 has a=(2d)/t^2. And this a=g

CIRCUIT DIAGRAM:

Connections of piezo electric sensors and photo interrupter with Arduino.



ARDUINO CODE:

```
const int ledPin= 13;
const int threshold=1;
long int endTime=0,startTime=0;
double Time;
float d=0.9;  //hight of
   photointerrupter from
   piezosensors
int count=0;

void setup()
{
  Serial.begin(9600);
  pinMode(ledPin, OUTPUT);

}

void loop()
{
  int val= analogRead(A0);    //
     analogpin connected to
     piezosensor-1
  int val2=analogRead(A1);    //
     piezosensor-2
  int val3=analogRead(A2);    //
     piezosensor-3
  int val4=analogRead(A3);    //
     piezosensor-4
  int val5=analogRead(A4);    //
     analogpin connected to
     photointerrupter
  Serial.print(val);
                 // printing values
      of each sensor on serial
     monitor
  Serial.print("␣");
  Serial.print(val2);
  Serial.print("␣");
  Serial.print(val3);
  Serial.print("␣");
  Serial.print(val4);
  Serial.print("␣");
  Serial.println(val5);

  if(val5>1000)    //when some
     object come in between
     interrupter analog pin becomes
      high
  {
    startTime=millis();
  }
  if (val>=threshold||val2>=
     threshold||val3>=threshold||
     val4>=threshold)
  {
   endTime=millis();
   Serial.print("EndTime␣:␣");
   Serial.print((float)endTime
      /1000);
   Serial.print("␣");
   Serial.print("StartTime␣:␣");
   Serial.println((float)startTime
      /1000);
```

```
    Serial.print("Time Of Flight : ");
    Time=(float)(endTime-startTime)/1000;
    Serial.println(Time);
    Serial.print("Acceleration of particle : ");
    Serial.println((d*2.0)/(Time*Time));

  digitalWrite(ledPin, HIGH);   // LED glowing
  delay(3000);
  digitalWrite(ledPin, LOW);
  delay(5000);
  }
  else
  {
  digitalWrite(ledPin, LOW);
  }
  delay(1);
}
```

OBSERVATION:

After uploading code, now open serial monitor and observe values of each sensor detecting. Now leave object from gap of photo interrupter and observe serial monitor. It will print the acceleration of the object.

RESULT:

Using this setup acceleration of freely falling object can be determined easily. And the result I got was in between 9-10 m/s^2 which is near to exact value 9.81 m/s^2.

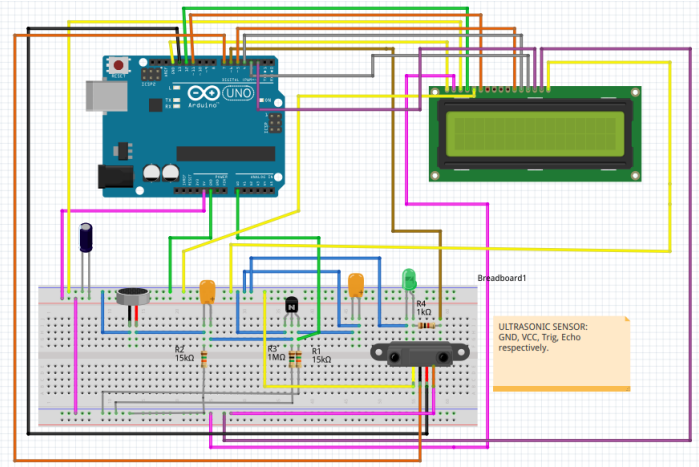
2.) Measurement of speed of sound using ultrasonic sensor and it's activation using clap switch

OBJECTIVE: measuring speed of sound. Making and using clap switch.

COMPONENTS:

- Arduino UNO
- Ultrasonic sensor
- LCD (16x2)
- Electret microphone
- 15k ohm – 2 resister
- 1M ohm – 1 resister
- 1k ohm -1 resister
- 1 LED
- 1-Capacotor (100 micro F)
- 2-capacitor(100nF)
- 2N3904 NPN transistor

CIRCUIT DIAGRAM:



connection of ultrasonic sensor, clap switch and LCD to Arduino UNO.

PERPARATION OF SETUP:

After making connection according to circuit diagram keep ultrasonic sensor against some barrier at measured distance and note this distance of barrier from sensor. Use this fixed distance in code of Arduino.

After preparing setup, upload following code to Arduino board.

ARDUINO CODE:

```
#include<LiquidCrystal.h>
LiquidCrystal lcd(12,11,5,4,3,2);
int sensorValue = 0,sensorValue1
   =0;
int trigPin=13,echoPin=7;
int distance=60;    // fixed
   distance in my case is 60cm.
int p=0,time;

void setup()
{
  lcd.begin(16,2);
  lcd.setCursor(0,0);
  lcd.print("Setup is ready");
  pinMode(6,OUTPUT);
  pinMode(trigPin,OUTPUT);
  pinMode(echoPin,INPUT);
  Serial.begin(9600);
}
void loop()
{
 sensorValue = analogRead(0);
 if(sensorValue>50)  // when
    microphone sense sound of high
    intensity
  {
  digitalWrite(6,HIGH);
  delay(1000);
  digitalWrite(6,LOW);
  delay(1000);
  p++;
  }
  if(p==1) // when clap switch
     becomes active then sensor
     becomes active
  {
     digitalWrite(trigPin,LOW);
     delayMicroseconds(2000);
     digitalWrite(trigPin,HIGH);
     digitalWrite(trigPin,LOW);
     time=pulseIn(echoPin,HIGH);
     p=(double)time/1000000;
    Serial.print("Speed of sound is
       :");
    Serial.print((float)(distance
       *2)/(p*100));
    Serial.println("m/s");
    lcd.setCursor(0,0);
    lcd.println("Velocity of sound"
       );
    lcd.setCursor(0,1);
    lcd.print((float)(distance*2)/(
       p*100));
    lcd.print(" ");
    lcd.print("m/s");
    delay(4000);
    lcd.setCursor(0,0);
    lcd.println("-setup is ready-")
       ;
    lcd.setCursor(0,1);
    lcd.println("                ");
    p=0;
  }
}
```

FORMULA:

Ultrasonic sensor is emitting sound wave of frequency higher than 20kHz which can't be detected by Human ears. Due to it's high frequency it distorts less and gets reflected if some barrier comes in between transmitter. After reflecting, this wave is detected by receiver.

Here we have fixed distance of barrier from transmitter and time taken by wave to come back to receiver is twice than time taken to travel fixed distance.

Time of travel= (time detected by sensor)/2

Speed = (fixed distance)/Time of travel.

Which is speed of sound.

WORKING PRINCIPLE OF CLAP SWITCH CIRCUIT:

Clap switch circuit consists of filter circuit and amplifier. Electret microphone when detect presence of sound waves it sends elecrical signals to RC filter. RC filter

removes noise from signals and send filtered signals to NPN transister. NPN transister amplifies signals it getting from RC filter and send it to analog pin of Arduino board where it's presence is detected and at appropriate signal strength, switch becomes active.

OBSERVATION:

After uploading code, clap loudly. Due to clap, clap switch becomes active and it will turn ON Ultrasonic sensor and LCD display and start calculating speed of sound depending upon the time taken by ultrasonic sound wave to travel fixed distance.

RESULT: Speed of sound measured using this setup is about 336 m/s^2. Which is closer to exact value 343m/s^2.

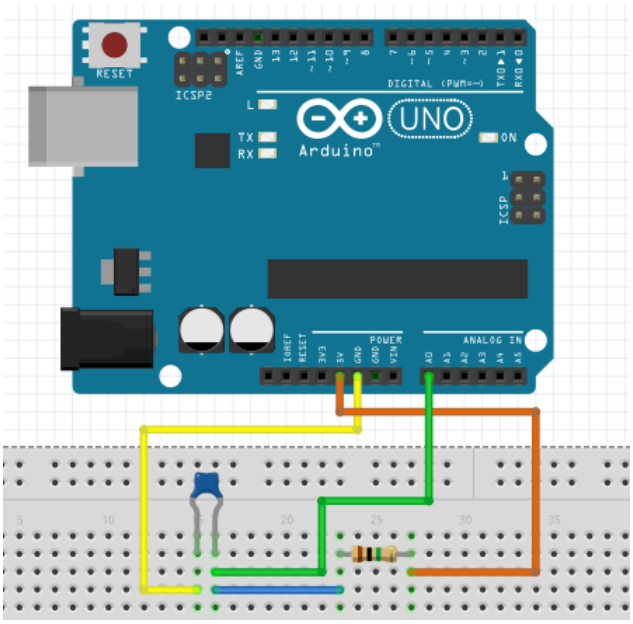
3.) analysis capacitor's charging and discharging curve from data obtained by Arduino.

OBJECTIVE: analysis of charging and discharging values of voltages with time.

COMPONENTS:

- 10 M ohm resister
- Capacitor of 0.44 micro F (use plastic film capacitor but don't use electrolytic capacitor)
- Arduino UNO

CIRCUIT DIAGRAM:



After making connections according to circuit diagram, upload following code to Arduino.

ARDUINO CODE:

```
float v1=0;
void setup() {
  Serial.begin(9600);
  Serial.println("CLEARDATA");
  Serial.println("LABEL,Computer␣
      Time,Time␣(Milli␣Sec.),Volt");

}

void loop() {
  v1=(float)5.0*analogRead(A0)
      /1024.0;
  Serial.print("DATA,TIME,");
  Serial.print(millis());
  Serial.print(",");
  Serial.println(v1);
  delay(100);
}
```

HOW TO OBSERVE CHARGING AND DISCHARGING VALUES OF VOLTAGE:

After uploading code open serial monitor, we will observe values of voltage across capacitor on serial monitor.

To observe charging value of voltage, first discharge capacitor by connecting it's both ends and then connect it to circuit.

To observe discharging value of voltage, disconnect 5V pin from Arduino after full charging of capacitor and connect extreme end of capacitor to another end of resister.

This way we can observe charging and discharging values of voltage on serial monitor.

How to print charging and discharging values of voltage directly to MS EXCEL:

MS Excel provides features to connect serial monitor directly to excel sheet. It provides better way to analyse data we are getting from Arduino and obtain results quickly.

For that we need to install "PLX-DAQ" in our windows.

We can refer following links to know how to install and use "**PLX-DAQ**" :

To install "PLX-DAQ" refer:
https://www.parallax.com/downloads/plx-daq

To know how to connect PLX-DAQ to excel refer:

https://medium.com/@islamnegm/quick-start-to-simple-daq-system-using-plx-daq-excel-arduino-d2457773384b

FORMULA:

During charging voltage varies as

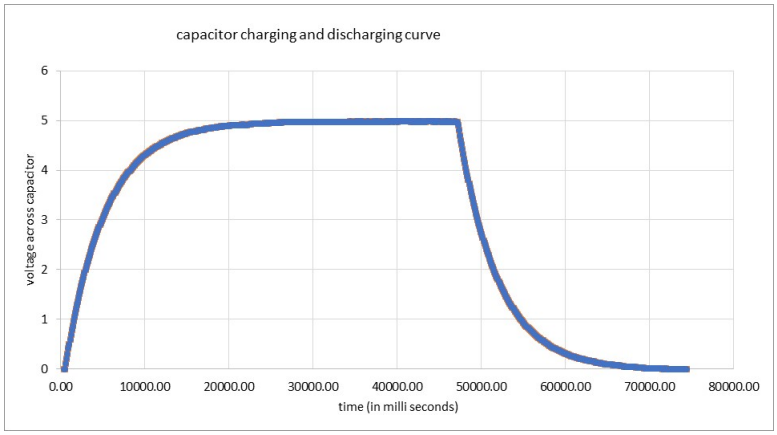
$$\mathbf{V(t)=}V_0\mathbf{(1-}e^{\mathbf{-(t-t1)/RC)}}\mathbf{).}$$

During discharging voltage varies as

$$\mathbf{V(t)=}V_0e^{\mathbf{-(t-t1)/RC}}\mathbf{.}$$

OBSERVATION:

I got this graph of charging and discharging of capacitor in EXCEL which is closer to the actual graph of charging and discharging according to relation of voltage with time.



RESULT:

This way very easily we can collect data through Arduino where observation of data at each milli seconds is important. This reduces error in observing data as we directly get data from Arduino to excel and observation becomes easy.
This type of analysis is useful when more than one circuit components are connected and we have to observe individual components.