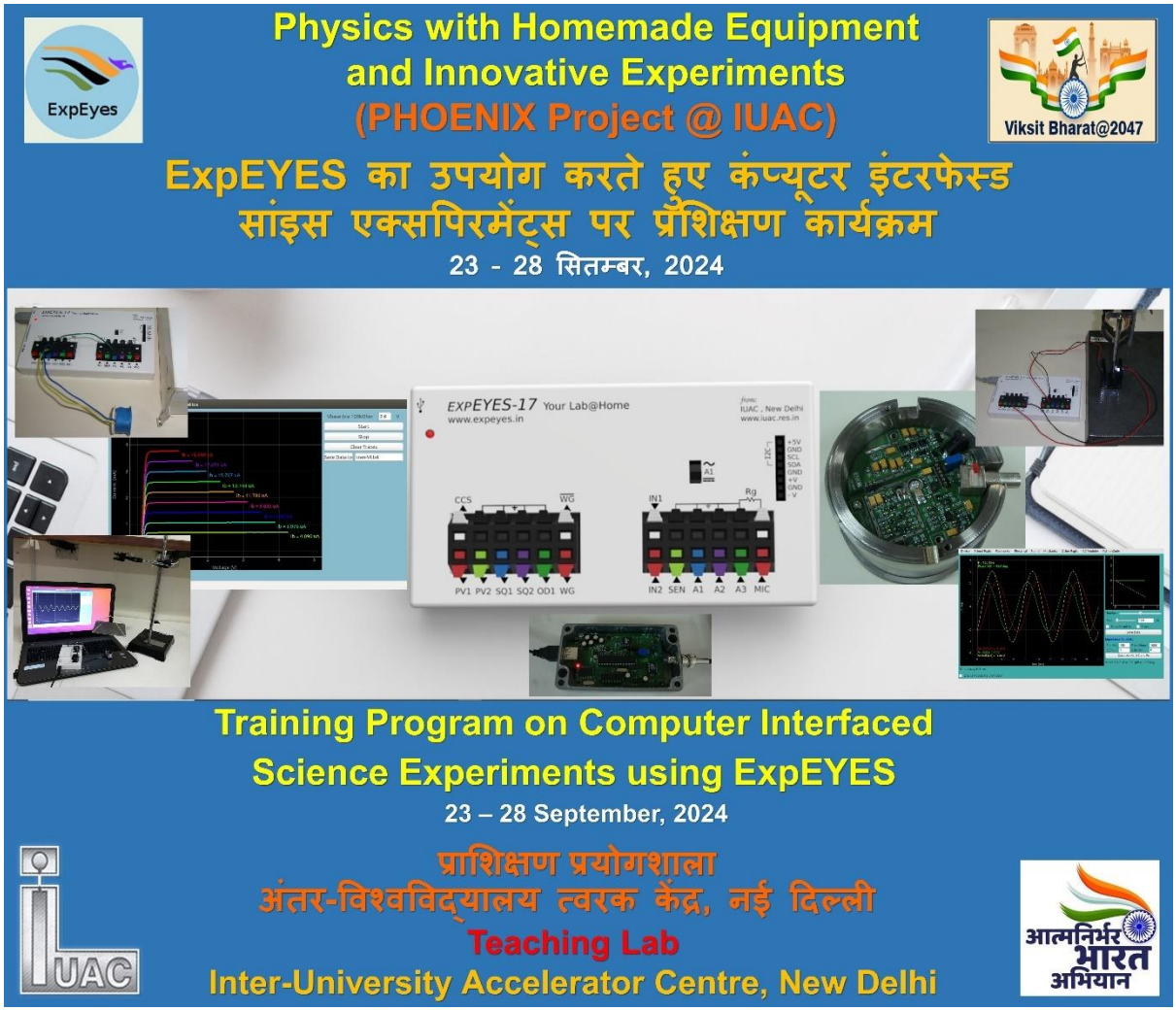
**Report on**

# Training Program on Computer Interfaced Science Experiments using ExpEYES




**Venue: Ph. D. Classroom**


अंतर विश्वविद्यालय त्वरक केंद्र
Inter-University
Accelerator Centre - (IUAC)

Aruna Asaf Ali Marg, Near Vasant Kunj,
New Delhi, 110067, INDIA

# Program Schedule

## Day 1: Monday 23rd September, 2024

| | | |
|---|---|---|
| 9:30 – 10:00 | **Registration** | |
| 10:00-10:30 | **Inaugural Program**<br>**Keynote Address by**<br>**Prof. Avinash Chandra Pandey, Director, IUAC** | |
| 10:30-11:15 | **Session-1**<br>**Design of Experiments** | **Prof O.S.K.S.Sastri,**<br>CUHP, Dharamshala. |
| 11:15-11:30 | **Tea** | |
| 11:30-12:00 | **Session-2**<br>**Teaching Science through Experimentation and Exploration** | **Shri. V.V.V.Satyanarayana**<br>IUAC, New Delhi |
| 12:00-13:00 | **Session-3**<br>**Introduction to ExpEYES** | **Prof Vandna Luthra**<br>Gargi College, New Delhi |
| 13:00-14:00 | **Lunch** | |
| 14:00-14:45 | **Session-4**<br>**Experiments using ExpEYES**<br>(Demonstration & Hands-on) | **Shri. V.V.V.Satyanarayana**<br>IUAC, New Delhi<br>**Prof O.S.K.S.Sastri,**<br>CUHP, Dharamshala.<br>**Prof Vandna Luthra**<br>Gargi College, New Delhi |
| 14:45-15:30 | **Hands-On Experiments** | |
| 16:00-16:45 | **Session-5**<br>Invited talk on<br>**Evaluation of Planck's Constant using Light Emitting Diodes: A new approach** (Online) | **Ms. Bidisha Biswas**<br>Bhairab Ganguly College, Kolkata. |
| 16:45-17:30 | **Projects – Discussions** | |

## Day 2: Tuesday 24h September, 2024

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|---|---|---|
| 09:30-11:00 | **Session-6**<br>**Classical Mechanics Experiments Demonstration & Hands-On** | **Prof O.S.K.S.Sastri,**<br>CUHP, Dharamshala<br>**Shri. V.V.V.Satyanarayana**<br>IUAC, New Delhi |
| 11:00-11:30 | **Tea** | |
| 11:30-13:00 | **Hands-On Experiments** | |
| 13:00-14:00 | **Lunch** | |
| 14:00-14:45 | **Session-7**<br>**Introduction to Tracker for Video and Image Analysis** | **Prof O. S. K. S. Sastri**<br>CUHP, Dharamshala |
| 14:45-15:30 | **Hands-On Experiments** | |
| 15:30-16:00 | **Tea** | |
| 16:00-16:45 | **Session-8**<br>**Innovative Approach to Teaching Ray Optics in the Classroom** | **Prof Amit Garg,**<br>Department of Electronics, Acharya Narendra Dev College, New Delhi. |
| 16:45-17:30 | **Hands-On Experiments** | |

## Day 3: Wednesday 25th September, 2024

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|---|---|---|
| 09:30–11:00 | **Session-9**<br>**Introduction to**<br>**Python Programming Language**<br>(Online) | **Dr Ajith Kumar B. P.**<br>Ex IUAC, New Delhi |
| 11:00-11:30 | **Tea** | |
| 11:30-12:30 | **Session-10**<br>**Android Mobile version of ExpEYES**<br>(Online) | **Dr Ajith Kumar B. P.**<br>Ex IUAC, New Delhi |
| 12:30-13:00 | **Hands-On Experiments** | |
| 13:00-14:00 | **Lunch** | |
| 14:00-14:45 | **Session-11**<br>**Interfacing ExpEYES**<br>**with Python** | **Prof Vandna Luthra**<br>Gargi College, New Delhi<br>**Shri. V.V.V.Satyanarayana**<br>IUAC, New Delhi |
| 14:45-15:30 | **Hands-On Experiments** | |
| 15:30-16:00 | **Tea** | |
| 16:00-16:30 | **Session-12**<br>**Thermal Sensitivity of Diodes:**<br>**An Automated Approach using ExpEYES**<br>(Online) | **Dr. Muhammad Ashefas C.H.**<br>Govt. Brennen College,<br>Thalassery, Kerala |
| 16:30-17:30 | **Hands-On Experiments** | |

## Day 4: Thursday 26th September, 2024

| | | |
|---|---|---|
| 09:30-10:15 | **Session-13**<br>Talk on<br>**Accelerators at IUAC** | **Shri. Abhijit Sarkar**<br>IUAC, New Delhi |
| 10:15-11:00 | **Session-14**<br>Talk on<br>**Alpha Spectrometer**<br>**Developed at IUAC** | **Shri. V.V.V.Satyanarayana**<br>IUAC, New Delhi |
| 11:00-11:30 | **Tea** | |
| 11:30-12:00 | **Hands-On Experiments** | |
| | **Lunch** | |
| 14:00-15:30 | **Hands-On Experiments** | |
| 15:30-16:00 | **Tea** | |
| 16:00-16:45 | **Session-15**<br>Talk on<br>**Python for ExpEYES** | **Ms. Surabhi Luthra**<br>Ph.D Student,<br>University College, London |
| 16:45-17:30 | **Project Preparations** | |

## Day 5: Friday 27th September, 2024

| | | |
|---|---|---|
| 09:30-10:15 | **Session-16**<br>**Demonstration of Physics Experiments using ExpEYES** | **Dr. Rajesh B.M.**<br>Department of Physics,<br>R V College of Engineering,<br>Bengaluru |
| 10:15-11:00 | **IUAC Facility Visit** | **Shri. V.V.V.Satyanarayana**<br>IUAC, New Delhi |
| 11:00-11:30 | **Tea** | |
| 11:30-13:00 | **Project Preparations** | |
| 13:00-14:00 | **Lunch** | |
| 14:00-15:30 | **Project Presentations by Participants** | |
| 15:30-16:00 | **Tea** | |
| 16:00-17:30 | **Project Presentations by Participants** | |

## Day 6: Saturday 28th September, 2024

| | |
|---|---|
| 09:30-11:00 | **Project Presentations by Participants** |
| 11:00-11:30 | **Tea** |
| 11:30-12:30 | **Distribution of Participation Certificates** |
| 12:30-13:00 | **Concluding Session** |
| 13:00-14:00 | **Lunch** |


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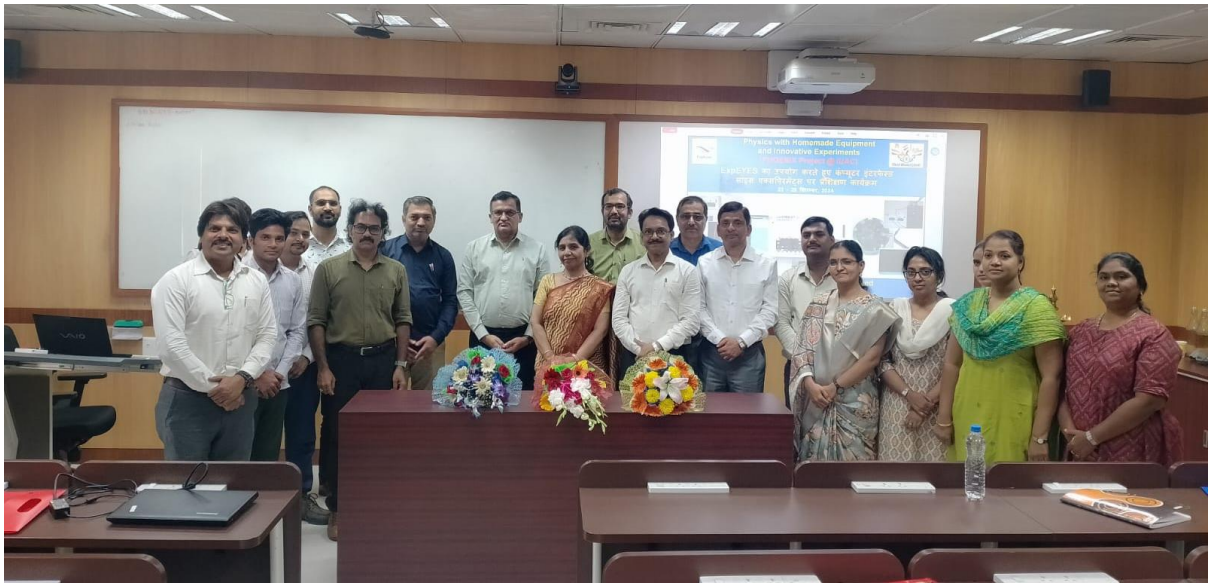



**Prof. A.C. Pandey, Director, IUAC with the Participants and Resource Persons during the Inauguration program**

Twenty-six participants were shortlisted out of 60 registrations for this training program and seventeen participants were able to attend. There were few last-minute cancellations because of few state-assembly elections duties, medical problems of the participants. This program included two resource persons: Prof. O. S. K. S. Sastri from the Central University of Himachal Pradesh, and Prof. Vandna Luthra from Gargi College, Delhi University, New Delhi. The criteria to shortlist the participants was to cover the participation from all parts of the country. Participation with booked travel tickets was mandatory to ensure the seriousness of the participants and also to avoid the opportunity of the interested participants, if any in the waiting list.

Every participant who selected was instructed to bring laptops with the ExpEYES software already installed. If someone doesn't have a laptop, they can share one with someone who does. Prior to the program, the ExpEYES-17 user manual, tentative experiment list, and program schedule were sent via the email and WhatsApp groups that had been created up especially for this purpose. To prepare the program schedule, the experiments were categorized by topic, and each day would have an introduction, a demonstration, and hands-on time for the participants. We attempted to include more hands-on sessions, which were the main means by which the experiments were demonstrated. There were plans to welcome guest speakers from IUAC and other sources both offline and online. To promote teamwork over individual work, two-person groups formed at the start of the training and each group received a single ExpEYES kit.

**List of the invited talks during the program in online and/or offline modes:**

1. **Introduction to Python Programming language and Android mobile version of ExpEYES (Online)**
   Dr. Ajith Kumar B.P., Ex IUAC, New Delhi.
2. **Introduction to Tracker for Video and Image Analysis**
   Prof. O.S.K.S.Sastri, CUHP, Dharamshala.
3. **Interfacing ExpEYES with Python Programming Language**
   Prof. Vandna Luthra, Gargi College, New Delhi.
4. **Evaluation of Planck's constant using LEDs: A new approach (Online)**
   Ms. Bidisha Biswas, Bhairab Ganguly College, Kolkata.
5. **Innovative approach to Teach Ray Optics in the Classroom**
   Prof. Amit Garg, Acharya Narendra Dev College, New Delhi.
6. **Thermal sensitivity of Diodes: An automated approach using ExpEYES (Online)**
   Dr. Muhammad Ashefas C.H., Govt. Brennen College, Thalassery, Kerala.
7. **Accelerators at IUAC**
   bShri. Abhijit Sarkar, IUAC, New Delhi.
8. **Demonstration of Physics experiments using ExpEYES (Online)**
   Dr. Rajesh B.M., R V College of Engineering, Bengaluru.
9. **Teaching Science with Experimentation and Exploration**
   Shri. V.V.V.Satyanarayana, IUAC, New Delhi.
10. **Python for ExpEYES**
    Ms. Surabhi, University College, London.

## Day 1: Monday 23rd September, 2024

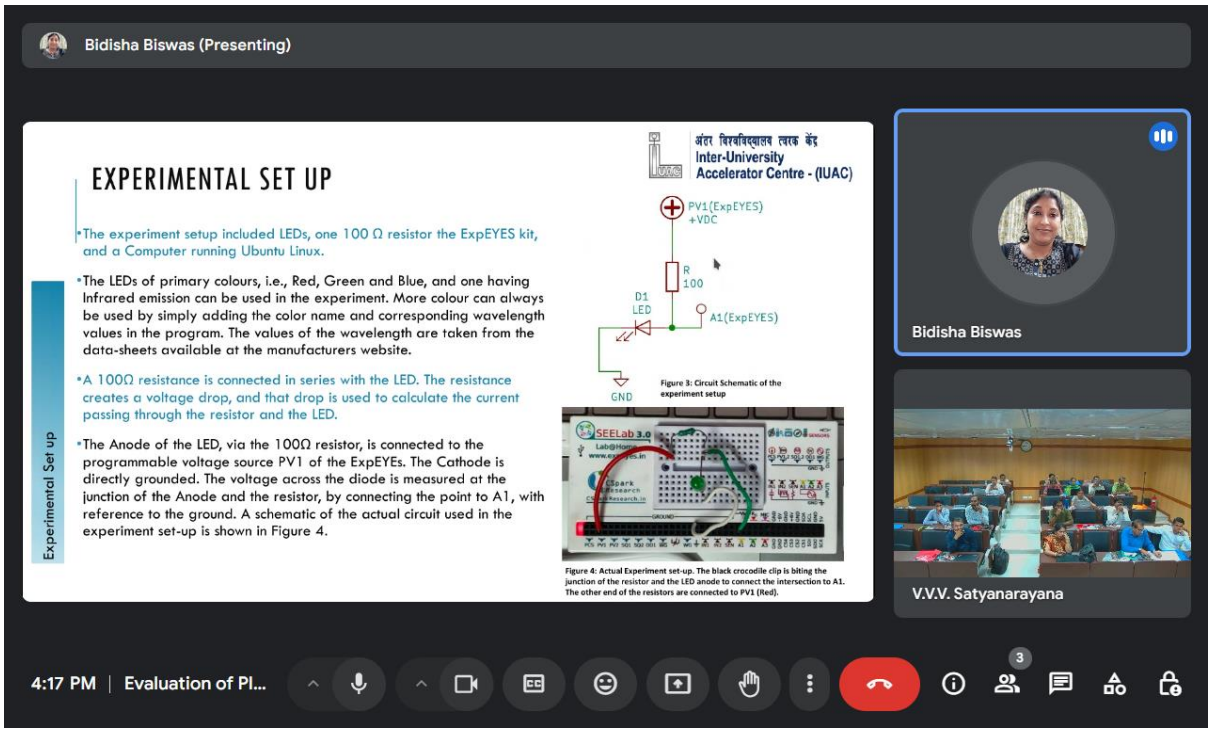


Shri. V.V.V. Satyanarayana welcomed the participants and the inaugural program was started with lamp lighting by the dignitaries. Prof. A.C. Pandey, director of IUAC, gave the keynote address, stating the objective of the program and the participant's responsibility to carry it forward at their respective locations in the form of holding similar programs, training students, and coming up with new experimental ideas. Prof. Vandna Luthra of Gargi College has been associated with this program for over ten years and appreciates IUAC for providing such a significant training program for the teaching community across the country. Shri. Abhijit Sarkar, Scientist-H, IUAC, extended gratitude to the dignitaries and congratulated the participants.

Prof. O.S.K.S. Sastri gave a talk titled "Design of Experiments" to start the post-inaugural session. Prof. Sastri talked about the availability and use of various sensors and transducers as well as the significance of interface tools. He discussed in great detail about the idea of designing sensor-based experiments and how ExpEYES may help with that. "Teaching Science through Experimentation and Exploration" was the title of the talk that Shri. V.V.V. Satyanarayana gave in the later session. He discussed how ExpEYES/Seelab3.0 can be used for classroom demonstration, performing physics, electronics, and electrical experiments for UG students, as well as how PG students can use it. He also discussed the significance of experiment-based science education.

Prof.Vandna Luthra and Shri.V.V.V. Satyanarayana explained the features of ExpEYES. They demonstrated ExpEYES as a multimeter with resistance, capacitance, and voltage

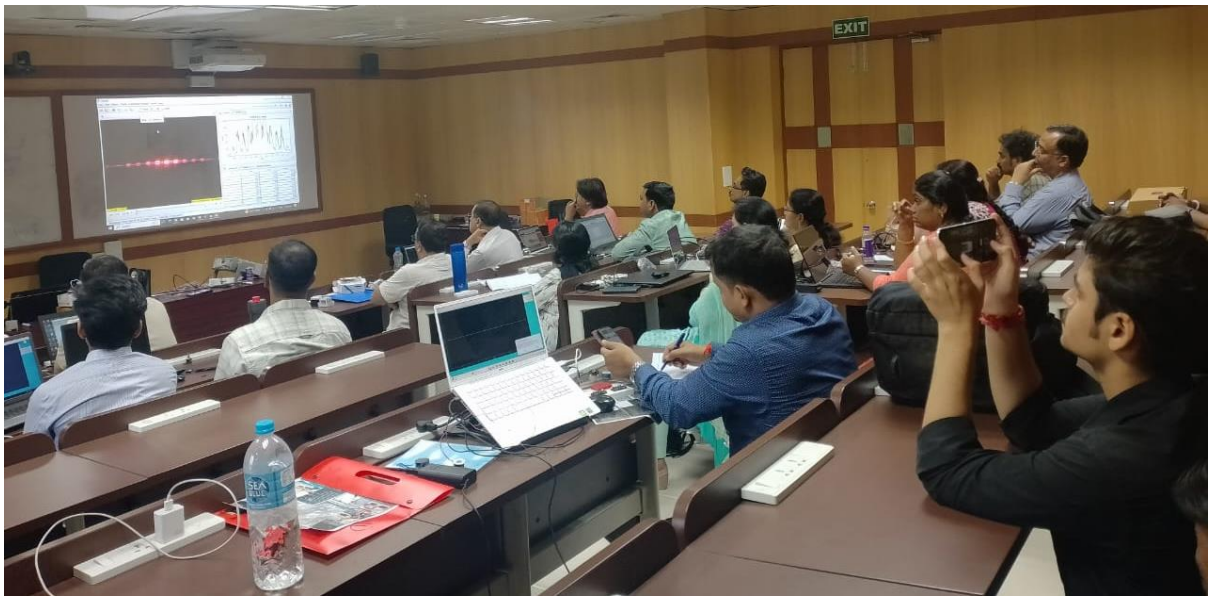
measurement capabilities, as well as a programmable power supply, waveform generator, and 4-channel oscilloscope. Participants had hands-on experience utilizing the hardware and software to measure DC and AC voltages using ExpEYES. In this session, the conventional way to plot the I-V characteristics of a PN junction diode with ExpEYES was demonstrated, as well as how this kit can help to expand this experiment in a given time.
This was followed by hands-on electronics experiments from the ExpEYES menu in the post-lunch session. By the evening, all of the participants were familiar with ExpEYES, and the majority of the experiments were carried out by individual groups of two participants.




Ms. Bidisha Biswas of Bhairab Ganguly college, Kolkata gave an invited talk titled 'Evaluation of Planck's constant using Light Emitting Diodes: A new approach' in online. The Planck's constant was found from the forward characteristics of Light Emitting Diodes. A separate Python program was written for this experiment.

## Day 2: Tuesday 24th September, 2024

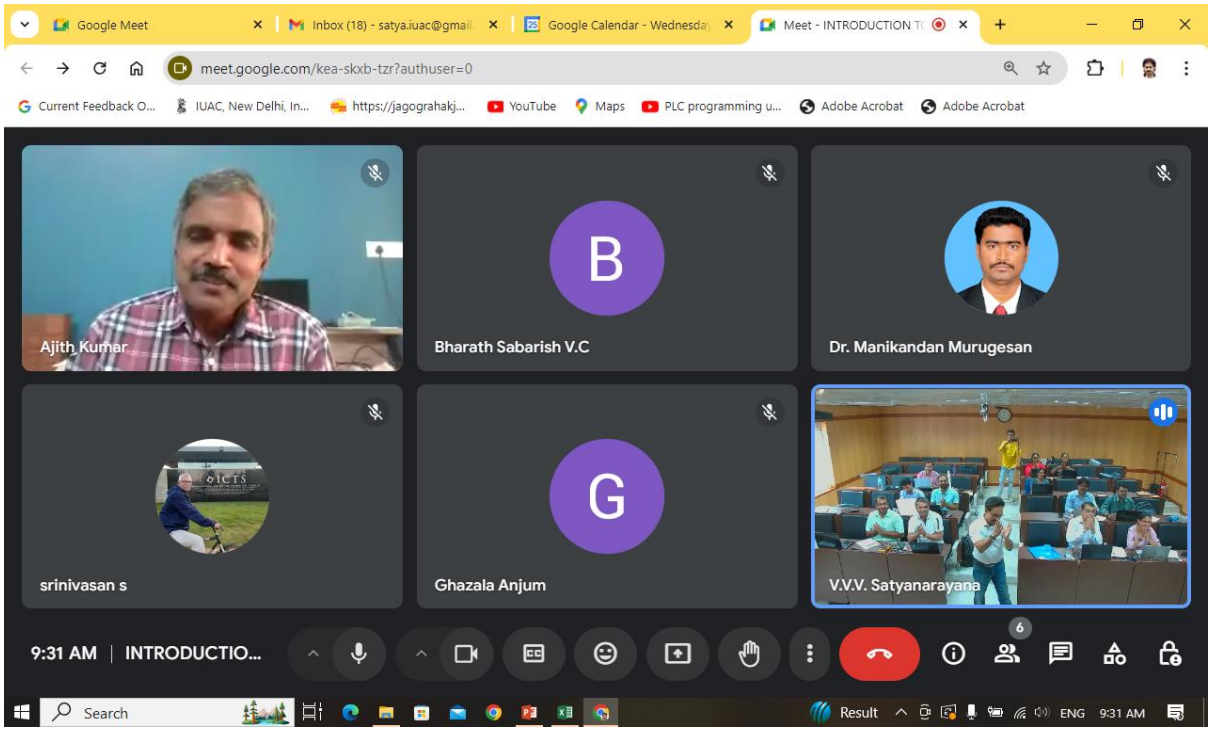
In the first session, Prof. O. S. K. S. Sastri, and V. V. V. Satyanarayana explained several classical mechanical experiments by demonstrating how to use various sensors, such as an ultrasonic echo sensor module for distance measurements, a photo-gate sensor for timing measurement, a DC motor as an angular position sensor, etc., with ExpEYES. The post-tea session was continued with hands-on practice of the mechanics experiments. Pendulum waveform digitizer, driven pendulum, Rod pendulum experiments were practiced during this session. Mass-Spring experiment has been performed using HC-SR04 Echo sensor module. Later, the participants
During the post-lunch session, Prof. Sastri gave a talk on 'Introduction to Tracker for Video and Image Analysis', which was followed by participants' hands-on experiments. Tracker software has been installed in the participants laptops and few examples have been practiced. Later, there were project discussions, and seven groups of two were formed with each group allotted one project.

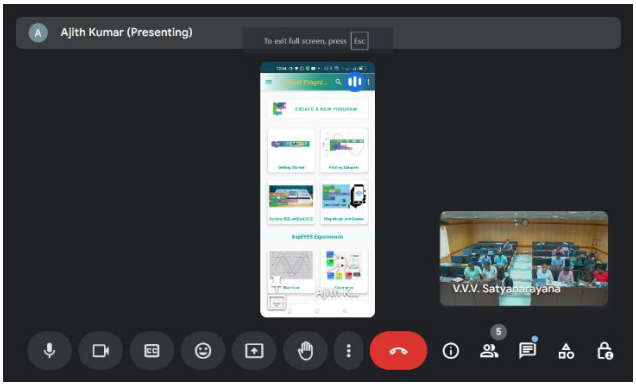

There was an invited talk and demonstration on “Innovative approach to Teach Ray optics in the classroom” by Prof. Amit Garg, Acharya Narendra Dev college, New Delhi. He along with his students demonstrated various optics experiments and provided the availability of these equipment and accessories. Later this talk, the participants continued hands-on experiments and almost most of the experiments given in the ExpEYES GUI menu list were covered by end of this day program.

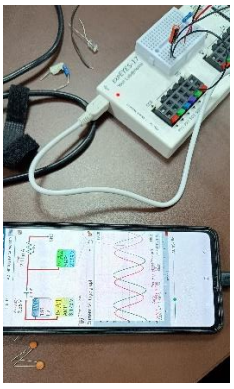
## Day 3: Wednesday 25th September, 2024

The morning session began with a talk on Introduction to Python programming language by Dr. Ajith Kumar B.P., Retired Scientist-H, IUAC, in an online mode. Dr. Ajith Kumar B.P., along with Shri. V.V.V. Satyanarayana started the PHOENIX project and Teaching Lab at IUAC and developed many versions of the ExpEYES and accessories to perform the experiments.

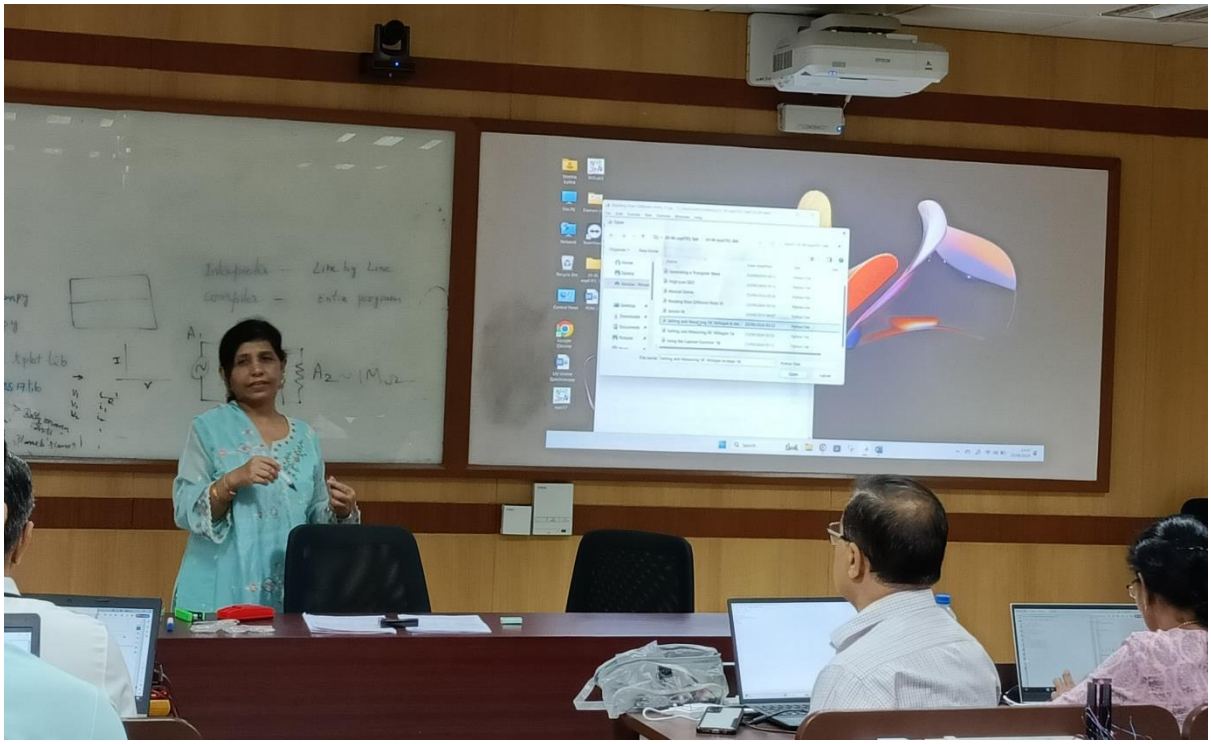



Very basic Python codes were introduced, as were the concepts of variables, data types, loops, etc. The participants were asked to write a small Python program for a given task by the end of this talk. By the end of this talk, the participants were able to establish the connection with ExpEYES kit and able to communicate through the Python programming language. Post tea session has allowed the participants to practice the Python commands to set voltages, reading the input data, plotting and showing the time variable signal inputs, etc. The post-tea session was continued by Dr. Ajith Kumar B.P and he demonstrated the use of 'Android Mobile Version of ExpEYES'. Mobile version software can be downloaded from the App Store, and a connection between the mobile device and ExpEYES can be established via an OTG cable and a USB cable combination.

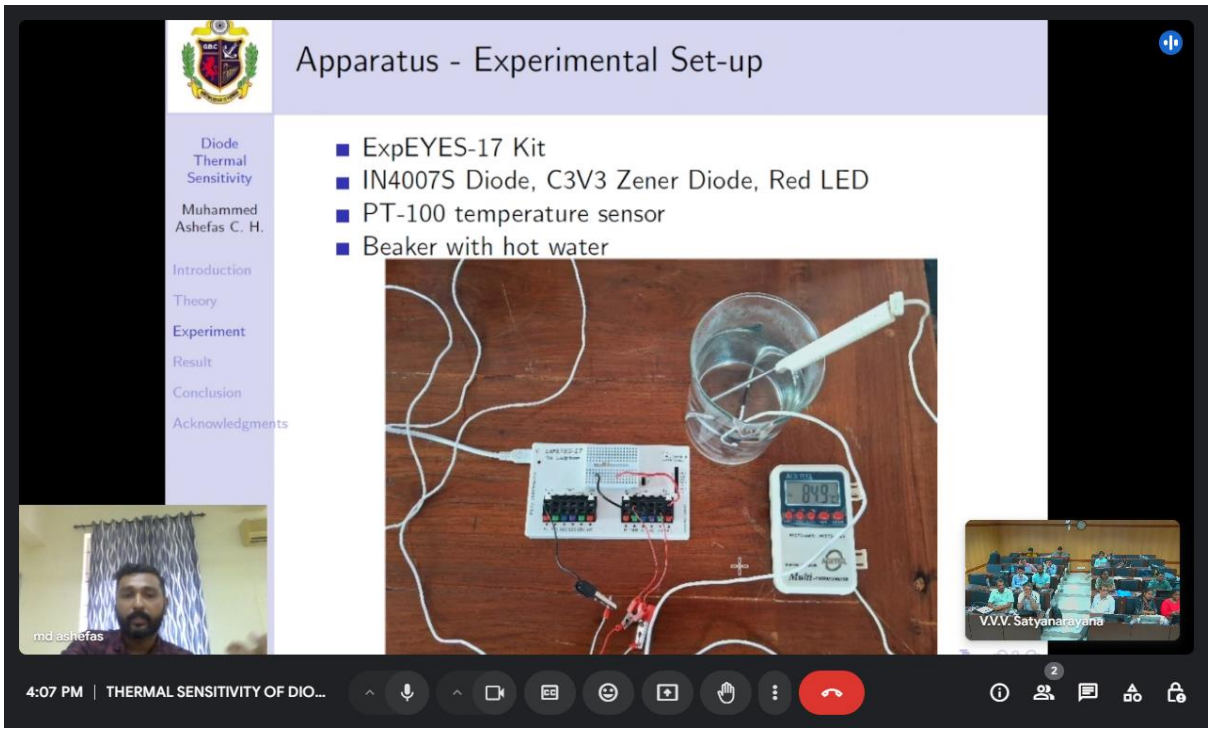


Various features and menu selections were demonstrated, and all participants practiced different experiments. It was also explained how useful this mobile version is for classroom demonstrations. Visual programming was also introduced in the mobile version. Later, hands-on explores with mobile and laptop versions were conducted. Prof. Vandna Luthra has once again explained and confirmed that all participants can interface with ExpEYES via Python instructions. This significantly increased the participants' confidence in utilizing the Python programming language with ExpEYES.



In the evening session a talk titled ‘Thermal Sensitivity of Diodes: An automated approach using ExpEYES’ was given by Dr. Muhammad Ashefas, Govt. Brennen College, Thalassery, Kerala in online mode. He has presented the work done by his students in which they have developed an automated approach and numerical method to find the thermal sensitivity of diodes using ExpEYES.



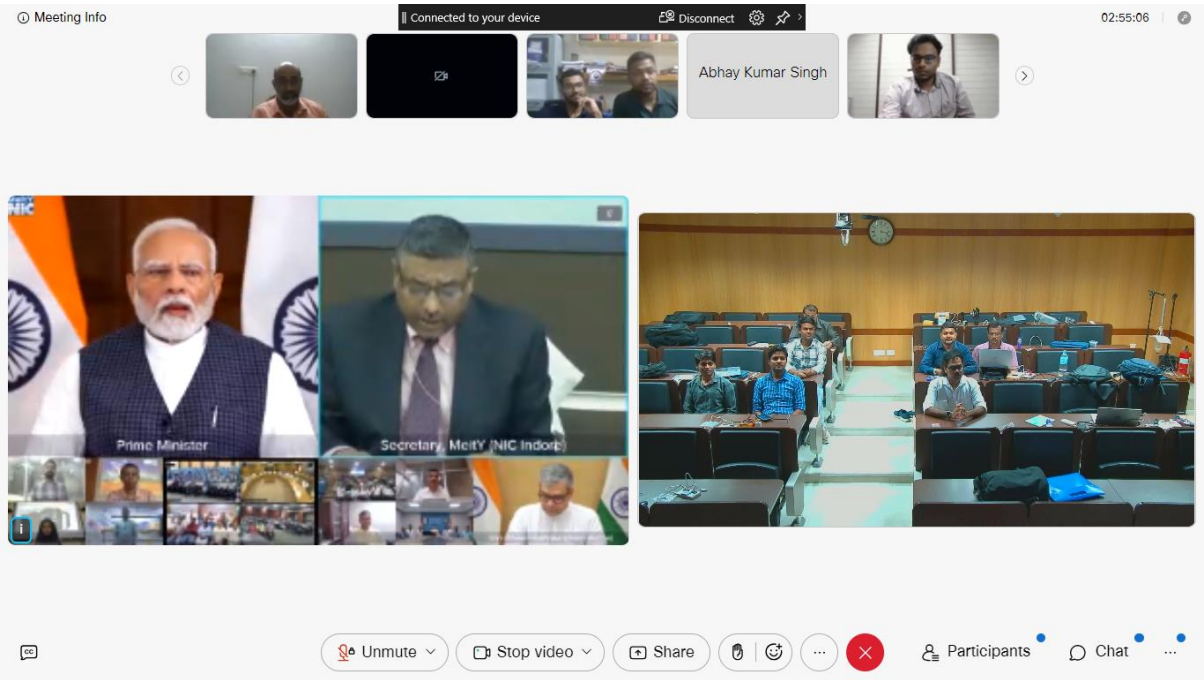
## Day 4: Thursday 26th September, 2024

In the morning session, a talk on **"Accelerators at IUAC"** was given by Shri. Abhijit Sarkar, Scientist-H, IUAC. The idea to include this talk during this training program was to use it as an acquaintance program to introduce the participants to the facilities available at IUAC for research applications. This may help the participants and associated students, if any, to utilize the facilities available at IUAC. The talk covered the various accelerator facilities available at IUAC, along with the energy levels of various accelerators.

Later, a talk and demonstration was given by Shri.V.V.V.Satyanarayana on the Signal processing and the Alpha Spectrometer developed at IUAC. The reason to initiate this development at IUAC and the history of various prototypes developed in this regard were discussed. The various types of experiments designed with this equipment were discussed and demonstrated. Using non-enriched sources to perform alpha particle detection experiments was discussed. Measuring the foil thickness, the study of alpha particle energy with distance in air, etc. were discussed. The signal processing of the detector's signals before acquiring the data was explained. The basics and necessity of each and every block of signal processing like pre-amplifiers, shaping amplifiers, peak-sensing ADCs, and data acquisition systems were explained in detail. The alpha spectrometer was demonstrated with $^{241}$Am alpha source with and without vacuum.

Pre and post lunch sessions were dedicated for hands-on and most of the experiments were practiced by almost all participants. Few of the participants have tried the experiments using Python codes given in the User manual.

In the evening there was program in which the prime minister Shri. Narendra Modi dedicated three **PARAM Rudra** Super computers to the nation via video conferencing. One supercomputer was setup at IUAC and the participants got an opportunity at attend this program.



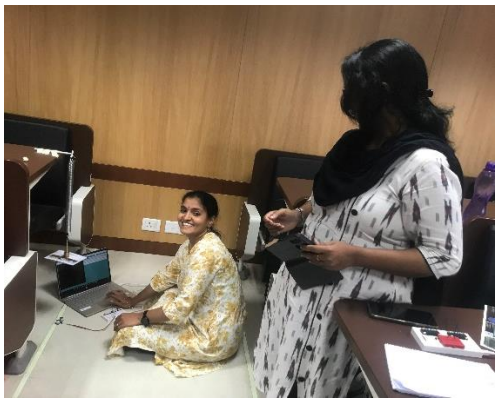

There were project preparations by the participants to be presented on 27th and 28th September 2024, as per the program schedule.

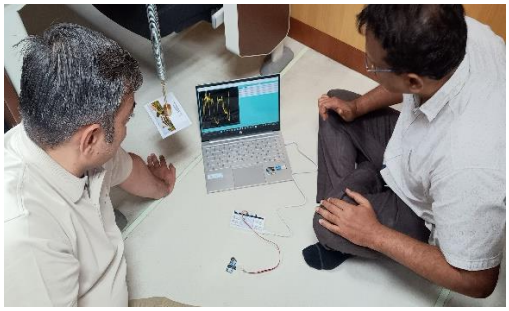
**The list of the projects taken by the participants:**

1. Measurement of resonant length using Sonometer by interfacing with ExpEYES.
2. Measurement of wind speed using ExpEYES & Transfer characteristics of Clipper circuits using ExpEYES.

3. Finding the length of the Pendulum with LIDAR sensor and ExpEYES.
4. Variable Mass Oscillator.
5. Finding thermal conductivity of a metal rod.
6. Revisiting the Free-Fall method for measuring gravity using Echo sensor and ExpEYES

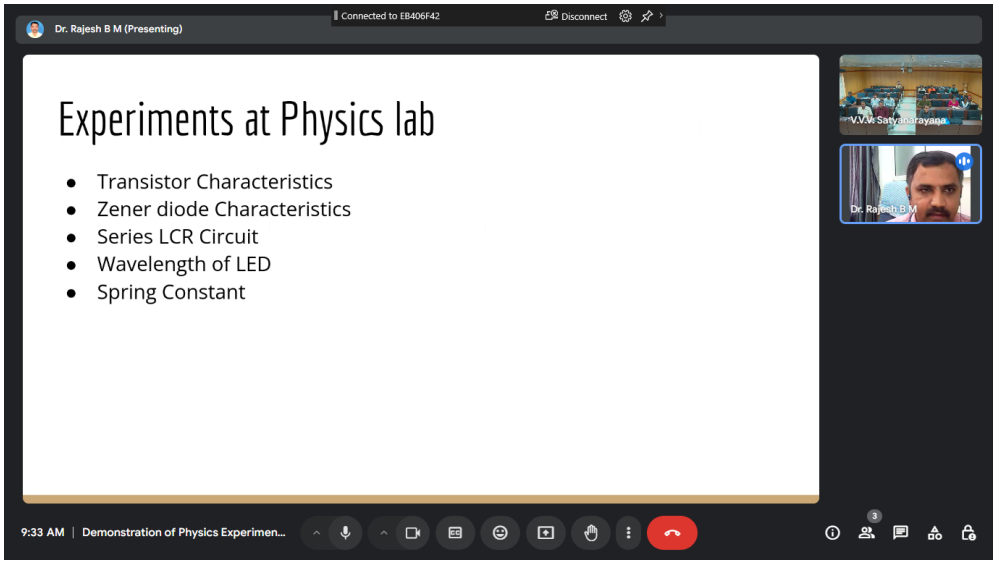
## Projects Preparations

## Day 5: Friday 27th September, 2024

In the morning session, a talk on **"Demonstration of Physics Experiments using ExpEYES"** was given in online mode by Dr. Rajesh B.M., R.V College of Engineering, Bengaluru. He has demonstrated various experiments which were created separate GUI programs and they include, device characteristics of diode, transistor, series LCR circuit, etc. The GUI program were developed by his students under his supervision.




## IUAC Facility Visit

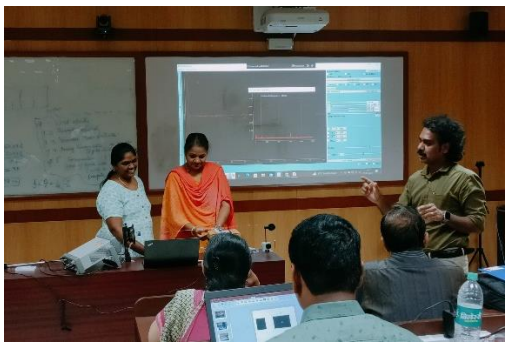
The purpose of the IUAC facility visit is to showcase the opportunities and resources available at IUAC to the Indian academic community so that they or their students can make use of them. The main control room and data room were among the accelerators, beam halls, and groups that participants visited during the visit. The post-lunch session was began with a talk on 'Python for ExpEYES' by Ms. Surabhi, Ph.D student, University College, London. Later, few project presentations were shown by the participants.

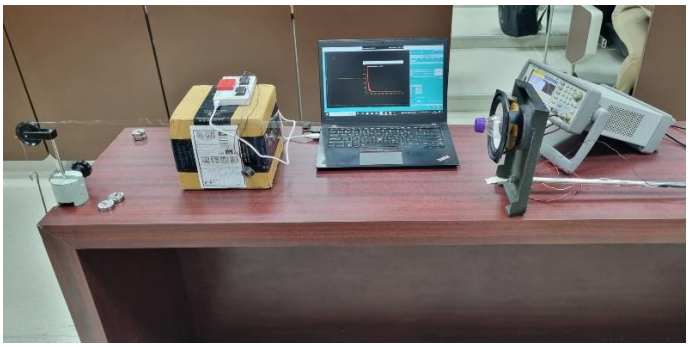

**Day 6: Saturday 28th September, 2024**

# Projects Presentations by the Participants

## Measurement of resonant length using Sonometer by interfacing with ExpEYES

Dr.N.Lavanya and Dr.Jidith Jayarani





The objective of this project is to measure the resonant length using sonometer by interfacing ExpEYES kit. In this experiment the apparatus used: Guitar String, electromagnet, loads (50 to 250g), Resistor (100 ohm), pully, Signal generator and ExpEYES17 kit. First the one end of the string is connected with the electromagnet and the electromagnet is connected to the waveform generator to apply frequency to the string. The other end of the string is connected to the loads and string is hanged with the help of the pulley.

This experimental arrangement is interfaced with ExpEYES using a coil connected to a magnet on the guitar string. The coil is connected between $A_3$ and ground terminals, 100 Ohms is connected between $R_g$ and ground. The experiment was done by applying frequency through the wave generator, the string is vibrated and the input frequency is monitored through the Fourier transform function available in ExpEYES. The experiment is repeated by varying the

frequency and loads. By measuring the frequency, mass and linear mass, the resonant length was calculated using the following formula:

The frequency n of the fundamental mode of vibration of a stretched string, fixed at two ends, is given by,

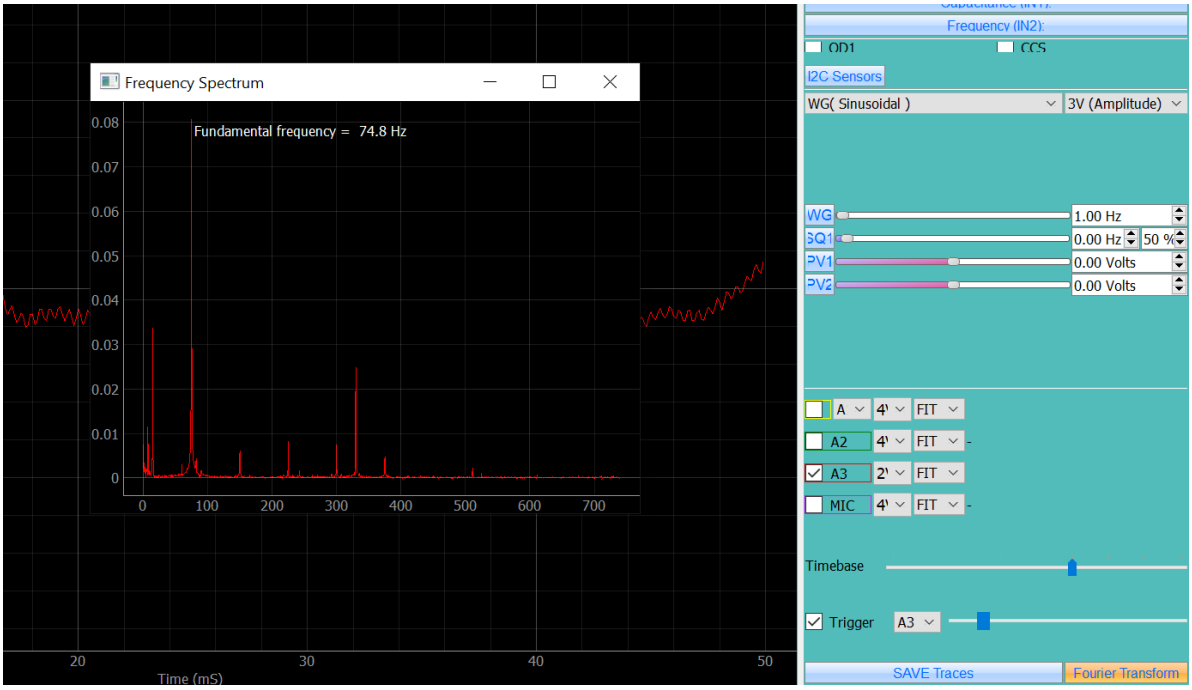
$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

Here l is the length of the vibrating string, T is the tension in the wire and m is its mass per unit length. If f is the frequency of the alternating current, then

$$f = \frac{n}{2} = \frac{1}{4l}\sqrt{\frac{T}{m}}$$

$$4n^2 l^2 m = T \qquad \text{or} \qquad l^2 = \frac{1}{4n^2 m} \times T$$

| String | Amplitude (V) | No. of Loops | Mass (g) | Frequency (Hz) | | Resonant Length(m) | Resonant Length(m) |
|---|---|---|---|---|---|---|---|
| | | | | Input | Output | | |
| I | 10 | 2 | 50 | 50 | 25 | 0.3298 | 0.6596 |
| I | 10 | 2 | 100 | 60 | 33.3 | 0.3888 | 0.7006 |
| I | 10 | 3 | 150 | 70 | 13.9 | 0.40824 | 2.0559 |




Fourier Transform with the frequency components

# Measurement of Wind Speed using ExpEYES

Dr.Ajesh A and Dr.Bhuvneshwar Suthar

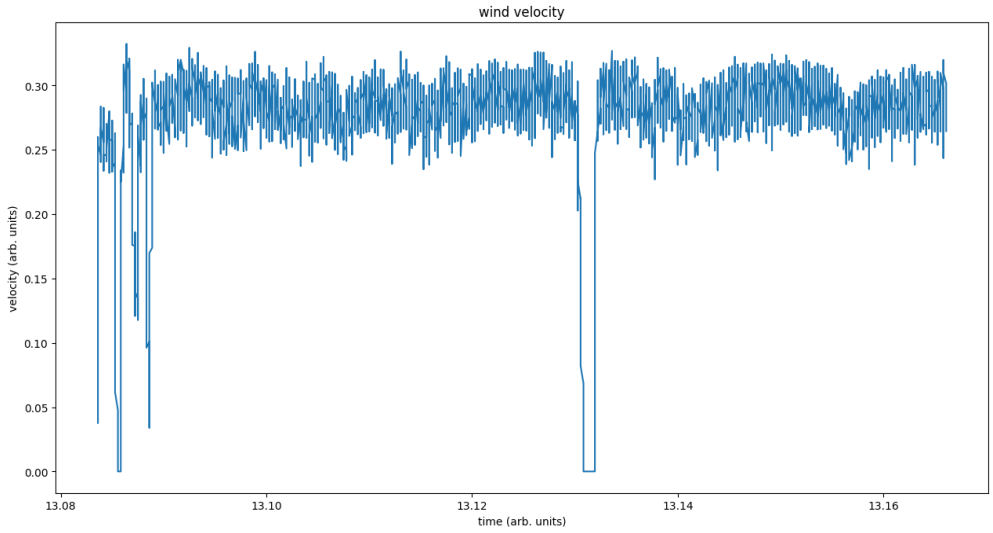

The first part of the experimental set up is to measure the voltage developed during various wind speed conditions using the dc motor as a generator; which produces voltage equivalent to the rotation of the fan attached to the shaft of the motor. The DC motor output is connected to the $A_1$ input and a fan and leaf mechanism is used to propel it to get the voltage signal proportional to the Velocity. The experimental set up has been tested using ExpEYES17 and the GUI for understanding the limiting values of the voltage generated. Then the same experiment has been run using python. The python output (time and voltage) has been plotted to graphically represent the results. The accurate wind speed measurements require either a wind tunnel or a calibrated anemometer.

A Python code was written and the code is:

File Edit Format Run Options Window Help

```
import eyes17.eyes
p=eyes17.eyes.open()
from pylab import*
import datetime
import time
import matplotlib.pyplot as plt
import numpy as np

t=0
ti=[]
vd=[]
while t<=10000:
#for t in range(100):

            v1=float(p.get_voltage('A1'))
            # Get the current date and time
            current_time = datetime.datetime.now()
            # Print the current date and time
            #print("Current date and time:", current_time)
            time = current_time.strftime("%Y-%m-%d %H:%M:%S")
            #print("Formatted date and time:", formatted_time)
            # Extracting specific components
            hour = float(time[11:13])     # '09'
            minute = float(time[14:16])  # '35'
            second = float(time[17:])     # '47'
            time=hour+minute/60+second/3600
            ti.append(time)
            if v1>= 0.03:
                    print(time, v1)
                    #ti.append(time)
                    vd.append(v1)
            else:
                    print(time, 0)
                    #ti.append(time)
                    vd.append(0)
            t=t+1
plt.plot(ti,vd)
title('wind velocity')
xlabel('time (arb. units)')
ylabel('velocity (arb. units)')
show ()
```

**Observations:**



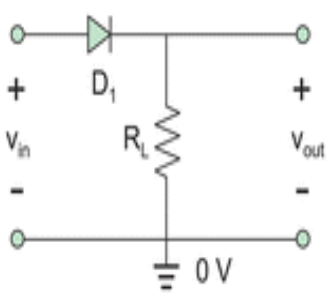

**Limitations:**

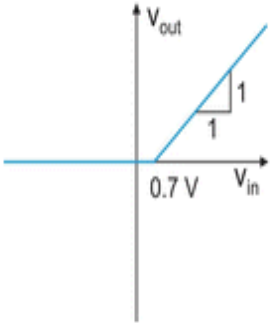
1. Accurate wind speed measurement requires calibrated anemometer.
2. Frictionless potentiometer or stepper motor is required for wind direction.
3. Friction has not been considered.

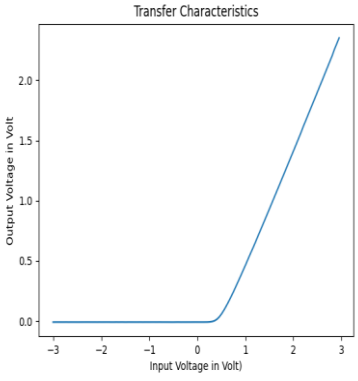
## Transfer Characteristics of Clipper Circuits using ExpEYES

Dr.Ajesh A and Dr.Bhuvneshwar Suthar

In the second part of the project, the performance evaluation of a clipper circuit has been done using Python aided by ExpEYES17 kit. This experiment has been done to understand and illustrate how the series and parallel clipper circuits works in positive as well as negative biases. The transfer characteristics have also been studied using the experimental set up. The data has been stored and represented graphically to better represent the results.



# Finding the length of the Pendulum with LIDAR sensor and ExpEYES

Dr. A. Vedavathi and Ms. Saptarsika Das


Objective is to accurately measure the length of a pendulum by analyzing its oscillatory motion using a Lidar sensor integrated with the ExpEYES-17 kit and Python for data acquisition and processing.

**Theoretical background:**

The time period of a simple pendulum of mass (bob) attached to a string, swinging under gravity is given by

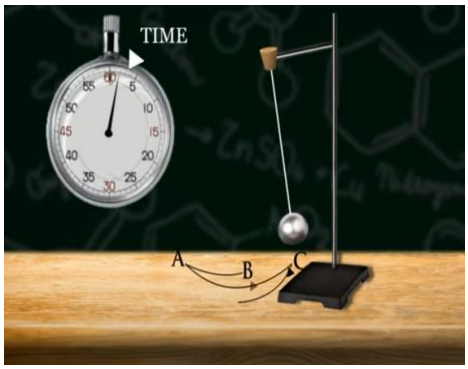
$$T=2\pi\sqrt{\frac{l}{g}} \quad \ldots\ldots\ldots\ldots (1)$$

[Where T= time period, $l$ = length of the pendulum, g= acceleration due to gravity (9.8 m/s$^2$ ]

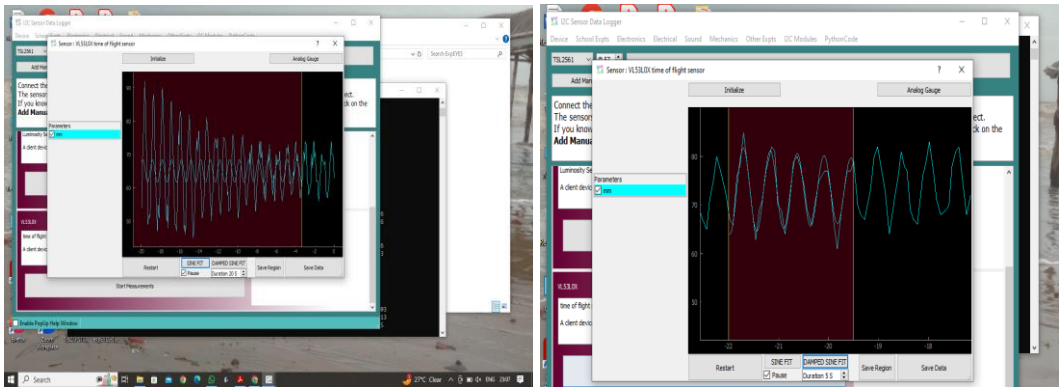
For our pendulum, the modified time period is $T=2\pi\sqrt{\frac{2l}{3g}}$ ……. (2)

Equation (2) is rearranged to find the length of the pendulum $l=\frac{3gT^2}{8\pi^2}$ …… (3)

**Experimental Setup:**




LIDAR sensor has been interfaced to ExpEYES 17 through I2C port of the kit. The sensor has been used to calculate the position of the pendulum at different instant of time. Data has been recorded for multiple oscillations over 10-20 periods for accuracy. The data acquisition has been done by using ExpEYES 17 and obtained the results given below.



**Experimental Data:**

| S No | Frequency in Hz | Length of the pendulum in cm |
|---|---|---|
| 1 | 1.879 | 10.55597 |
| 2 | 1.890 | 10.43457 |
| 3 | 1.880 | 10.54587 |
| 4 | 1.876 | 10.59089 |
| 5 | 1.855 | 10.83204 |
| | | Avg=10.59187 |

For Bar pendulum

| S No | Frequency in Hz | Length of the pendulum in cm |
|---|---|---|
| 1 | 1.081 | 31.89677 |
| 2 | 1.081 | 31.89677 |
| 3 | 1.083 | 31.77907 |
| 4 | 1.008 | 36.68403 |
| 5 | 1.032 | 34.99763 |
| | | Avg=33.45085 |

For Scale Pendulum

**Sources of errors:**

- Air resistance
- Sensor alignment
- String rigidity
- Sampling rate limitations

**Conclusion:**

In this experiment, the length of the pendulum was successfully measured using LIDAR sensor, ExpEYES. Demonstrated the integration of hardware and software in experimental set up. The experiment depicted the importance of accurate data acquisition and analysis. Finally, through this project practical application of theoretical physics principles was demonstrated.

# Variable Mass Oscillator

Dr.Rajesh Arora and Dr.Ankit Kumar Gupta

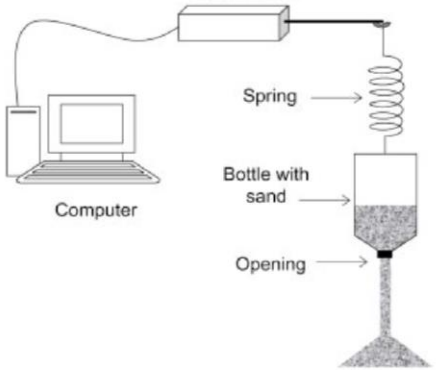
Objective is to accurately measure the study the motion of variable mass oscillator.

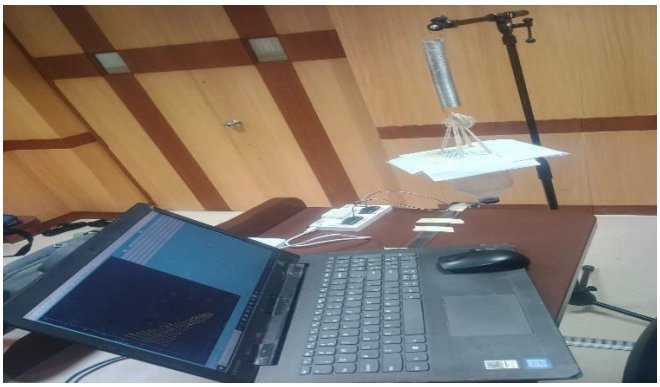
**Theoretical background:**

For a spring-mass system, the frequency and mass can be defined as, when the mass has increased the frequency will decrease and when the mass has decreased the frequency will increase.

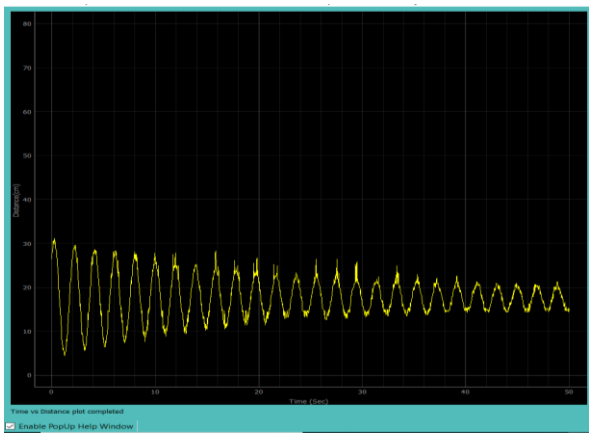
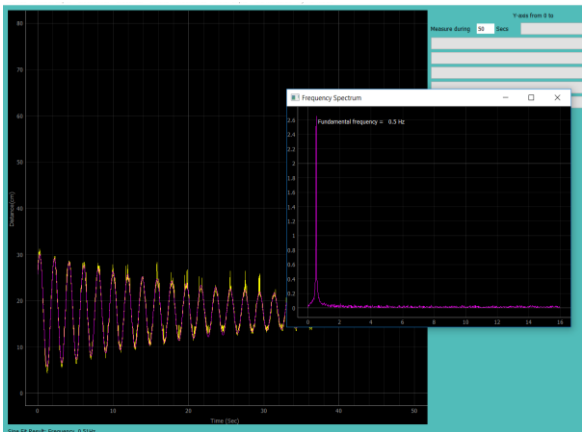
$$\omega=\sqrt{\frac{k}{m}}$$

Here, f is the frequency and m is the mass. Hence, the mass and frequency are inversely proportional to each other.

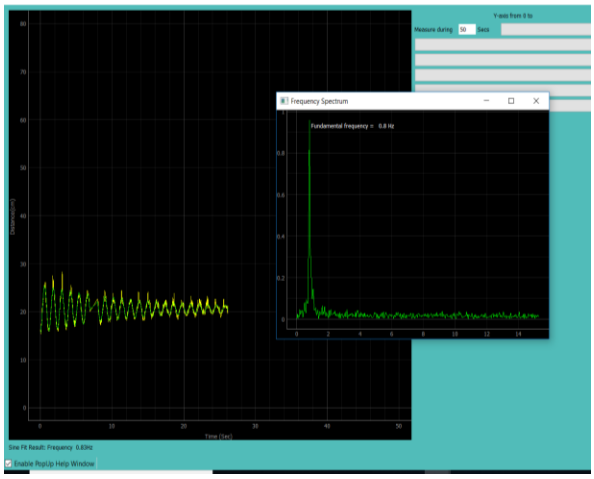


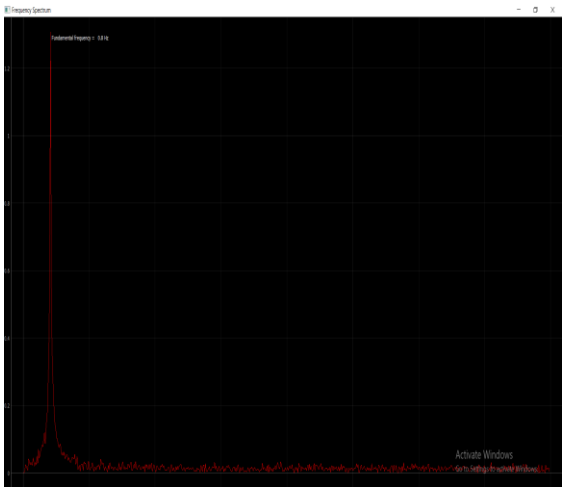



Piezo sensor has been interfaced to ExpEYES. The sensor has been used to calculate the position of the oscillator with variable mass at different instant of time. Data has been recorded for multiple oscillations over 10-20 periods for accuracy. The data acquisition has been done by using ExpEYES and obtained the results shown below.

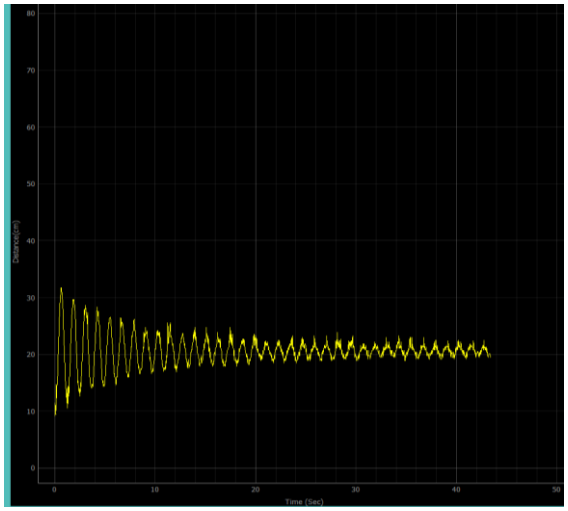



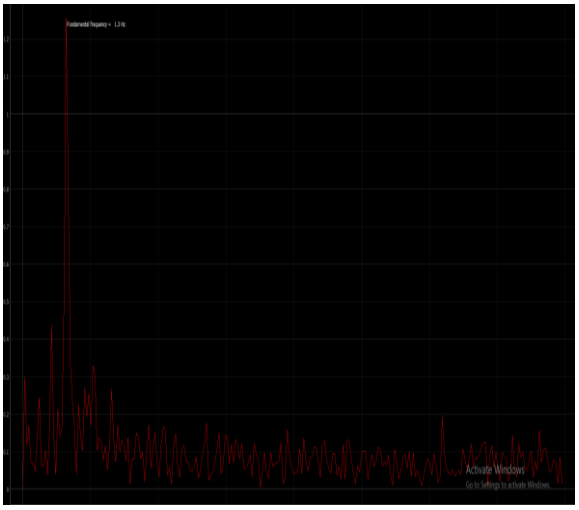

For 200 grams weight






For 100 grams weight






For least mass

**Experimental Data:**

Frequency & Time period measuring with varying mass

| S.No | Mass (g) | Frequency (Hz) | Time Period (T) |
|---|---|---|---|
| 1 | 200 | 0.5 | 2 |
| 2 | 100 | 0.8 | 1.25 |
| 3 | Least Mass | 1.3 | 0.769 |

**Conclusion:**

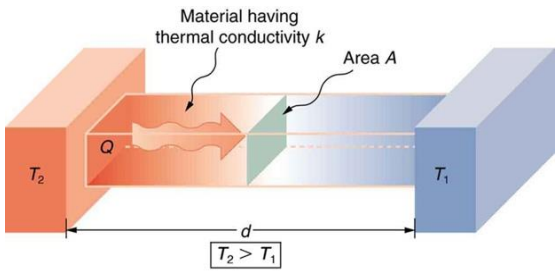
In this experiment, we successfully measured the frequency of the mass oscillator using Piezo sensor and ExpEYES kit. We have verified the variation of frequency with variable mass and time period of oscillation.

## Finding the Thermal conductivity of a Metal Rod

Akash P Gokhe and Ashish Kumar

**Introduction:**

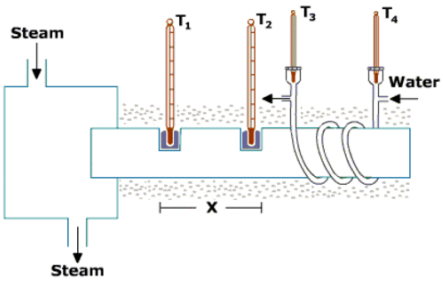
Thermal Conductivity: Thermal conductivity is a material's ability to conduct heat, indicating how efficiently heat can transfer through the substance. It is typically measured as the amount of heat transferred per unit time, per unit area, per unit temperature gradient.



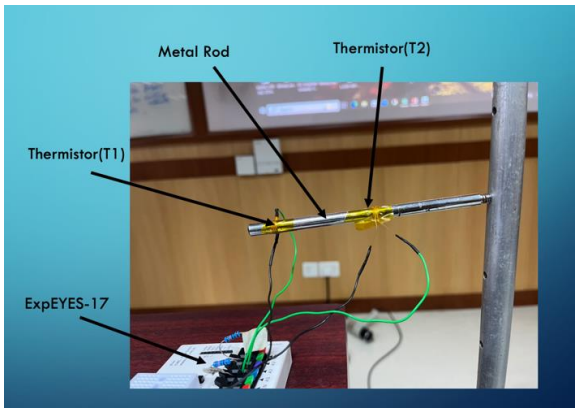
**Theory:**

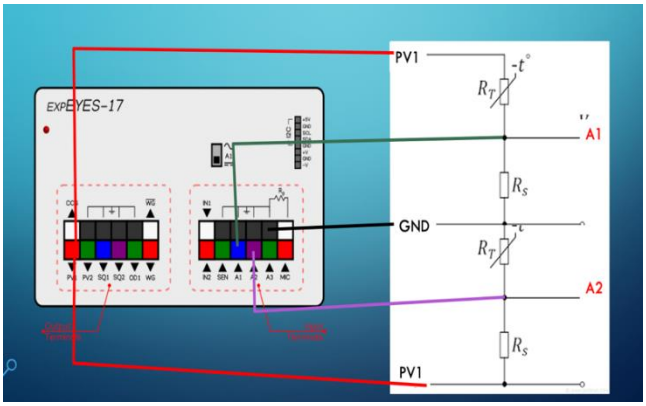
$$K = \frac{QL}{A(T_1 - T_2)}$$

- Q is the heat input (in watts)
- L is the distance between the two thermometers (in meters)
- A is the cross-sectional area of the material (in square meters)
- $T_1$ and $T_2$ are the temperatures at the two points (in Kelvin or Celsius).




**Experimental setup:**




A voltage divider circuit using a thermistor allows temperature measurement by converting temperature-dependent changes in the thermistor's resistance into a corresponding change in output voltage. As the thermistor's resistance decreases with increasing temperature, the output voltage adjusts, enabling temperature sensing.

$$V_{out} = V_{in} \times \frac{R}{R + R_t}$$

Where:

- $V_{in}$ is the input voltage.
- R is the resistance of the fixed resistor.
- $R_T$ is the resistance of the thermistor (which varies with temperature).
- $V_{out}$ is the output voltage across the fixed resistor.

**Python Code:**

Link to download file

**Conversion of voltage into temperature:**

```
def voltage_to_temperature(voltage, R_fixed=100000, B=3950, R0=10000, V_in=5.0):
    R_thermistor = R_fixed * (V_in / voltage - 1)  # Calculate thermistor resistance
    T0 = 297.15  # Reference temperature in Kelvin (25°C)
    #temperature = 27 + (R_thermistor - 10000) / 150
    temperature = 1 / ((1 / T0) + (1 / B) * math.log(R_thermistor / R0))  # Temperature in Kelvin
    return temperature-273  # Convert to Celsius
```

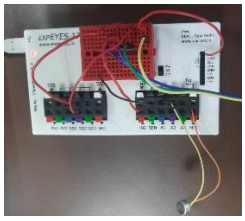
**Calculation of thermal conductivity:**

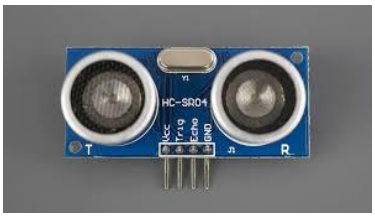
```
temp_1 = []
temp_2 = []


#print(f"Temperature 2: {temperature2:.2f} °C")

k = []
Time = []
t = 0
while t<100:
    p.set_pv1(5.0)
    v = p.get_voltage('A1')
    v1 = p.get_voltage('A2')
    temperature1 = voltage_to_temperature(v)
    temperature2 = voltage_to_temperature(v1)
    temp_1.append(temperature1)
    temp_2.append(temperature2)
    del_t = temperature1 - temperature2
    K =  (15*7)/(math.pi * 0.4 *0.4*(temperature1 - temperature2))
    k.append(K)
    Time.append(t)
    time.sleep(1)

    print(f"Temperature 1: {temperature1:.2f} °C", f"Temperature 2: {temperature2:.2f} °C")
    print("Thermal conductivity: ",K)
    t+=1
```

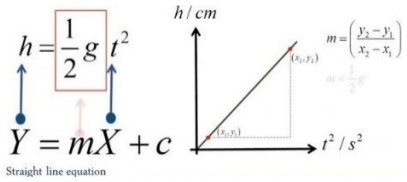
# Revisiting the Free-Fall method for measuring the Gravity using Echo sensor with ExpEYES

Dr. Manoj Kumar and Dr. Nikhil Kumar

Measurement of acceleration due to gravity (g) is one of the fundamental experiments in undergraduate physics. Typically, the free-falling body method is used to estimate this parameter. This experiment involves measuring the time taken by an object to fall a known distance, using the relationship between height, acceleration due to gravity, and time:






In a traditional setup, the distances used in the lab are often of the order of 1 meter, resulting in very short fall times, typically a few hundred milliseconds. As a result, highly sensitive timing devices are required to ensure accurate measurements. Using *ExpEYES* and its associated distance sensor, the same experiment can be performed with added advantages. This system not only replicates the results of the traditional experiment but also provides additional information, such as position-versus-time data. In a typical free fall over 1 meter, ExpEYES can collect 6 to 8 data points, enabling students to analyze the fall in greater detail.

This added information enhances the learning experience by allowing students to study the motion more comprehensively. They can replicate the experiment and better understand the relationship between the parameters of free fall.

**Experiment results:**

| S. No. | Distance (cm) | g (cm/s$^2$) |
|---|---|---|
| 1. | 80 | 921.41 |
| 2. | 80 | 1405.26 |
| 3. | 80 | 1053.92 |
| 4. | 80 | 872.26 |
| 5. | 80 | 1011.21 |
| 6. | 80 | 941.45 |
| | $g_{avg}$ | 1034.25 |

Percentage of Error ~ 5.4%

**Source of Error:**

1. Air resistance
2. Non-uniform object
3. Complete free-fall

The project presentations were stared on 27th September 2024 and the remaining presentations were done on the last day of the program. There were seven projects presented and few of them were really interesting and innovative in the methods followed.

## Concluding Session

Concluding session was started with the distribution of the participation certificates.

During the concluding session, Shri.Abhijit Sarkar informed the participants about IUAC's efforts in this project and congratulated Shri. V.V.V. Satyanarayana and his team on continuing this program by involving the best teaching faculty in the country, such as Prof. Sastri, Prof. Vandna Luthra, and other resource persons. It was advised to the participants that they should transfer the knowledge and objectives of this program to their respective locations in the form of classroom demonstrations, conducting short workshops with adjacent institutions, incorporating students in traditional experiments using ExpEYES, etc. It was also communicated to the participants to keep the WhatsApp group active by sharing information about the training program and any new developments based on the knowledge and experience obtained from this program.

As Shri. Abhijit Sarkar, Scientist-H, is set for retirement on December 31, 2024, the organizers and participants taken this occasion to congratulate him on the last Teacher training program at IUAC. Shri. Abhijit Sarkar promised participants that he would surely take this program to the various educational institutions in his area and seek help and cooperation from everyone if necessary.

# List of the Participants

| # | Name of the Participant | Institute |
|---|---|---|
| 1 | Dr. Vedavathi Aluri<br>Assistant Professor | Department of Physics, Sri Sathya Sai Institute of Higher Learning, Anantapur |
| 2 | Dr. Bhuvneshwer Suthar<br>Assistant Professor | Govt. Dungar College, Bikaner |
| 4 | Dr. RAJESH ARORA<br>Associate Professor | DYAL SINGH COLLEGE, KARNAL (HARYANA) |
| 5 | Dr. Ajesh A<br>Assistant Professor | Department of Physics, Kariavattom Campus, University of Kerala, Thiruvananthapuram, Kerala. |
| 6 | Dr. Akash Pralhad Gokhe<br>Assistant Professor | Sagar University, Sausar, Chhindwara M.P. |
| 7 | Mr. Saralasrita Mohanty<br>Scientific Officer-E | 206, D1 Block, NISER Bhubaneswar |
| 8 | Dr. Ankit Kumar Gupta<br>Assistant Professor | School of Applied Sciences, Suresh Gyan Vihar University, Jaipur |
| 9 | Dr.N.Lavanya<br>Associate professor of Physics | A.D.M.college for women, Nagapattinam |
| 10 | Dr. JUDITH JAYARANI.A<br>Assistant Professor | PG & Research Department of Physics, Bishop Heber College, Trichy, Tamil Nadu. |
| 11 | Dr. Manoj Kumar Gundawar<br>Professor | University of Hyderabad<br>University of Hyderabad, Hyderabad |
| 12 | Dr. Nikhil Kumar<br>Assistant Professor | Department of Physics,<br>DDU Gorakhpur University, Gorakhpur, Uttar Pradesh |
| 13 | Ms. Saptarsika Das<br>State Aided College Teacher | Department of Electronics, Rishi Bankim Chandra College, East Kanthalpara, Naihati,North 24 Parganas, West Bengal |
| 14 | Mr. Ashish Kumar<br>Research Scholar | Department of physics, Chandigarh University, Mohali, Punjab |
| 15 | Prof O.S.K.S.Sastri<br>Resource Person | Central University of Himachal Pradesh, Dharamshala |
| 16 | Prof Vandna Luthra<br>Resource Person | Gargi College, New Delhi |
| 17 | Ms. Bidisha Biswas<br>Invited Speaker | Bhairab Ganguly College, Kolkata |
| 18 | Dr. Ajith Kumar B.P.<br>Resource Person | Ex-IUAC, New Delhi |
| 19 | Dr. Muhammad Ashefas C.H.<br>Invited Speaker | Govt. Brennen College, Thalassery, Kerala |
| 20 | Dr. Rajesh B.M.<br>Invited Speaker | R V College of Engineering, Bengaluru |
| 21 | Prof. Amit Garg<br>Invited Speaker | Acharya Narendra Dev College, New Delhi |
| 22 | Ms. Surabhi<br>Invited Speaker | University College, London |
| 23 | Mr. Upender Singh<br>Electronics Apprentice | IUAC, New Delhi |
| 24 | Mr. Om Mishra<br>Electronics Apprentice | IUAC, New Delhi |
| 25 | Mr. Ajay Rajak<br>Audio/Video Support | IUAC, New Delhi |

Teacher Training Program on

# Computer Interfaced Science Experiments using ExpEYES

**September 23–28, 2024**

## Inter-University Accelerator Centre

Aruna Asaf Ali Marg, New Delhi

## Experiments for Young Engineers and Scientists

Science is the study of the physical world by systematic observations and experiments. Proper science education is essential for cultivating a society where reasoning and logical thinking prevails and not superstition and irrational beliefs. Science education is also essential for training enough technicians, engineers and scientists for the economy of the modern world. It is widely accepted that personal experience in the form of experiments and observations, either carried out by students or performed as demonstrations by teachers, are essential to the pedagogy of science. Teaching lab started with the objective of developing cost effective equipment for teaching science. The basic technique followed is to provide Analog and Digital Input/Output capabilities to a computer through the input/output connectors on the interfacing equipment. Experiments are designed utilizing these I/O capabilities and suitable sensor elements to convert physical parameters into voltage signals. Inter-University Accelerator Centre, New Delhi, conducts different kinds of programs to promote the innovative way of doing Science experiments as a part of Outreach program.

### Tentative Speakers

Dr. Ajith Kumar B.P., Ex IUAC
Prof. OSKS Sastri, CUHP, Dharamshala
Prof. Vandna Luthra, Gargi College, New Delhi
Dr. Bidisha Biswas, Bhairab Ganguly College, Kolkata
Dr. Rajesh B.M., R V Engineering College, Bengaluru
Dr. Muhammed Ashefas C.H., Govt. Brennen College, Kerala
Prof. Amit Garg, Acharya Narendra Dev College, New Delhi
Shri. Abhijit Sarkar, IUAC
Shri. V V V Satyanarayana, IUAC
Ms. Surabhi Luthra, University College, London

### Link for Registration

https://docs.google.com/forms/d/1k3nTGB0it_UtwWPxFRKTCVT8Jt8XERrG-KkLG7KDGsY/edit

### Contact Persons

Shri. V V V Satyanarayana & Shri. Abhijit Sarkar
Email: iuacteachinglab@gmail.com

प्राशिक्षण प्रयोगशाला
Teaching Lab

अंतर विश्वविद्यालय त्वरक केंद्र
Inter-University Accelerator Centre - (IUAC)