

Developing a physics laboratory in the developing world

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<http://physlab.lums.edu.pk>



LUMS School of Science & Engineering

What's so unique about (several) developing countries?

“For the first year at the Raman Research Institute there was no electricity, but that did not deter Raman from carrying out several beautiful optical experiments with sunlight, a few lenses and a pair of polaroids. He considered a beam of sunlight as the best source, and in Bangalore there was no shortage of blue sky and bright sun. A manually-operated heliostat, kept in operation by voice communication, produced astonishing results.”

- Jayaraman, A., *Chandrasekhara Venkata Raman - A Memoir*, Affiliated East-West Press, New Delhi, 1989.

The main challenges

- Importation versus indigenous development
- **Misplaced emphasis on imported, costly equipment**
- Time commitment for development
- Acceptability of developing course material, especially laboratory material (hardware, ideas)
- Institutional support
- Where are the developers?
- Elite and non-elite physics
- **Colonial legacies?** Mind is supreme over the hand.

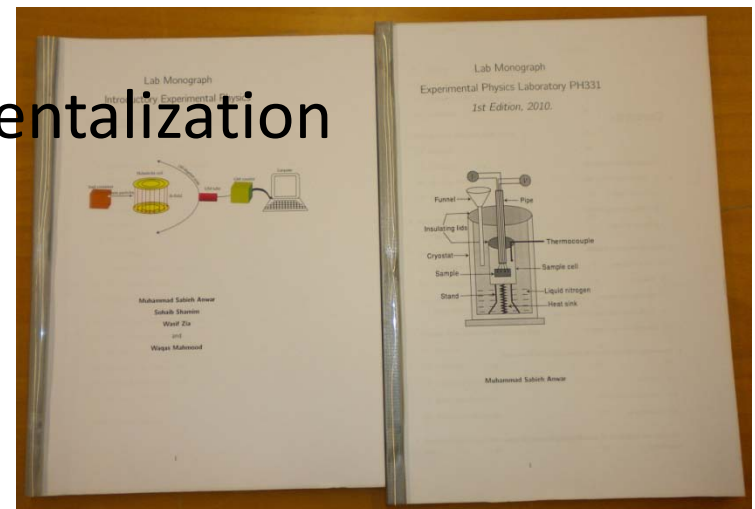


Philosophy of laboratory courses

- Are lab courses hand maiden to the “theory” courses or do they have a life of their own?
- Simulations or real experiments
- Virtual or remote experiments

The main opportunities

- Learn lots of new physics from different areas
- Extract ideas for research, fuelling “mainstream” physics research
- Avoiding excessive compartmentalization of scientific knowledge



Sample page from national curriculum – prior to reform

LAB-I

1 Cr.h

Pre-requisites

Intermediate with Physics and Math or A level Physics

Objectives

To develop the experimental capability of students in understanding the concept of Mechanics.

1. Modulus of Rigidity by Static & Dynamic method (Maxwell's needle, Barton's Apparatus).
2. To study the damping features of an oscillating system using simple pendulum of variable mass.
3. Measurement of viscosity of liquid by Stoke's / Poiseulli's method.
4. Surface tension of water by capillary tube method.
5. To determine the value of "g" by compound pendulum / Kater's Pendulum.
6. To study the dependence of Centripetal force on mass, radius, and angular velocity of a body in circular motion.
7. Investigation of phase change with position in traveling wave and measurement of the velocity of sound by C.R.O.
8. Determination of moment of inertia of a solid/hollow cylinder and a sphere etc.
9. To study the conservation of energy (Hook's law).

Recommended Books:

D. H. Marrow, Selected Experiments in Physical Sciences, Longman.

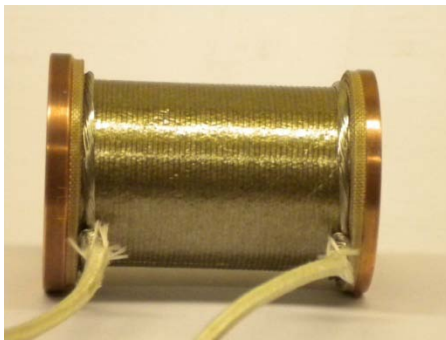
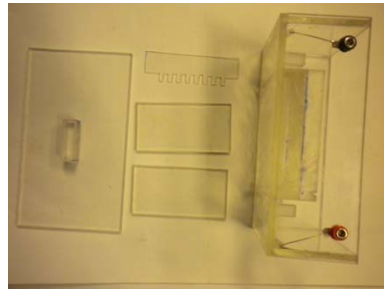
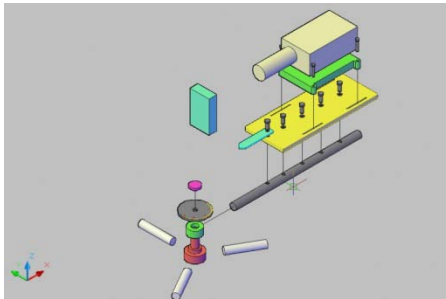
Nelkon and Ogborn, Advanced Level Practical Physics, Heimann Educational Books

Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.

C. K. Bhattacharya, University Practical Physics, CBS Publishing

Phases of development

- Establish a mechanical workshop
- Engage a team of developers – dedicate staff
- Learn key skills – mechanical design, knowledge of materials, glass blowing, electroplating, handling plexiglass, computer interfacing (see next slides), excellent scientific communication, making electric heaters, PID control, electronic circuit and PCB making



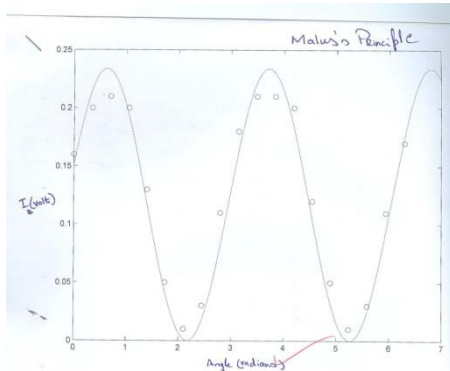
See what Raman has to say...

“My immediate task is to get my Research Institute functioning vigorously I have recently purchased some workshop equipment and an oxygen plant, which I hope to convert into a liquid nitrogen plant. I lack many things, notably a building to house the workshops and a hostel for the research workers, as well as funds needed for the recurring expenditure.”

- The Hindu, February 3, 1949.

Special emphasis areas

- Uncertainties (GUM approach)
- Writing laboratory notebooks
- Ethical practices, patience
- Take away emphasis from producing flowery reports: logging versus reporting
- Plotting, sketching and graphing
- Safety first



(19) $\alpha = 0^\circ$
 $I_{\max} = 0.22 \text{ V}$
 $\beta_{\max} = 220^\circ$

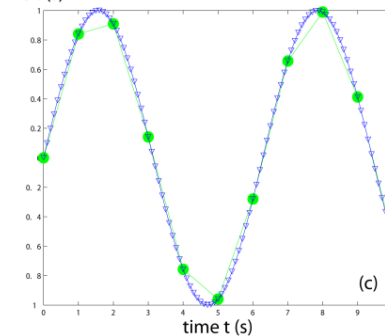
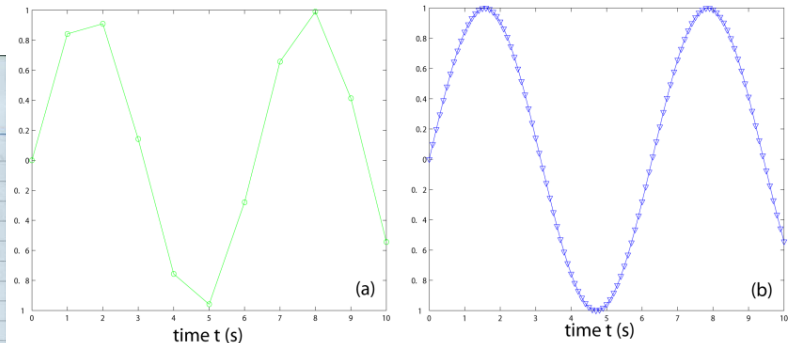
(2) $I_{\min} = 0.00 \text{ V}$
 $\beta_{\min} = 300^\circ$
 Angular diff = $300 - 220 = 80^\circ$

(22)

$$I_{1/2} = \frac{0.00 + 0.22 - 0.00}{2} = \frac{0.22}{2} = 0.11 \text{ V}$$

$$\beta_{1/2} = 260^\circ$$

α	β_{\max}	$I_{\max} \text{ (V)}$	β_{\min}	$I_{\min} \text{ (V)}$	$\beta_{1/2}$	$I_{1/2} \text{ (V)}$
0	220	0.22	300	0.00	260	0.11
20	250	0.22	320	0.00	280	0.11
40	254	0.20	348	0.00	302	0.10
60	100	0.21	182	0.00	142	0.10
80	120	0.22	202	0.00	162	0.11
100	138	0.22	42	0.00	82	0.11
120	340	0.21	248	0.00	282	0.11
140	164	0.21	88	0.00	128	0.10
160	202	0.20	280	0.00		0.10
180						
200						



Outreach and transferring experiments to other Universities

2nd Annual Open House Physics Laboratory Work 2011



Date: Tuesday, 25 October 2011

Time: 4-6 pm

Venue: 2nd floor, Physics Laboratory, SSE Complex
LUMS School of Science & Engineering
<http://physlab.lums.edu.pk>

Contact for registration:

Arshad Maral: arshad.maral@lums.edu.pk

Dr. Sabieh Anwar: sabieh@lums.edu.pk

Who should attend: University and college teachers in Physics

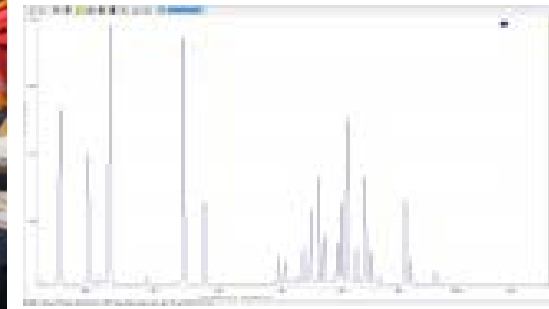
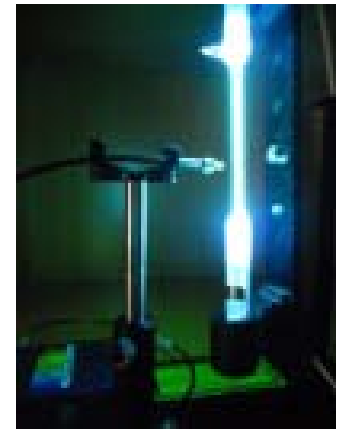






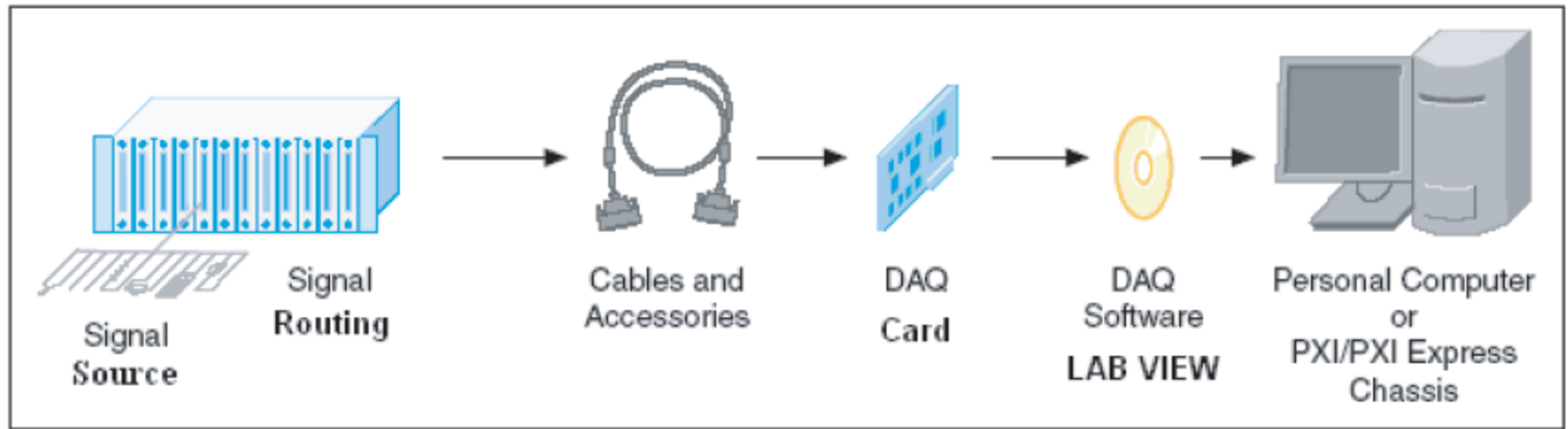
Some other snippets

- Classroom demonstrations
- Summer interns can become developers of new experiments
- Blueprints for lab courseware is made available on the website
- Pictorial procedures for high throughput classes



Computer Interfacing and data acquisition

Data acquisition cards



Webcams and digital cameras

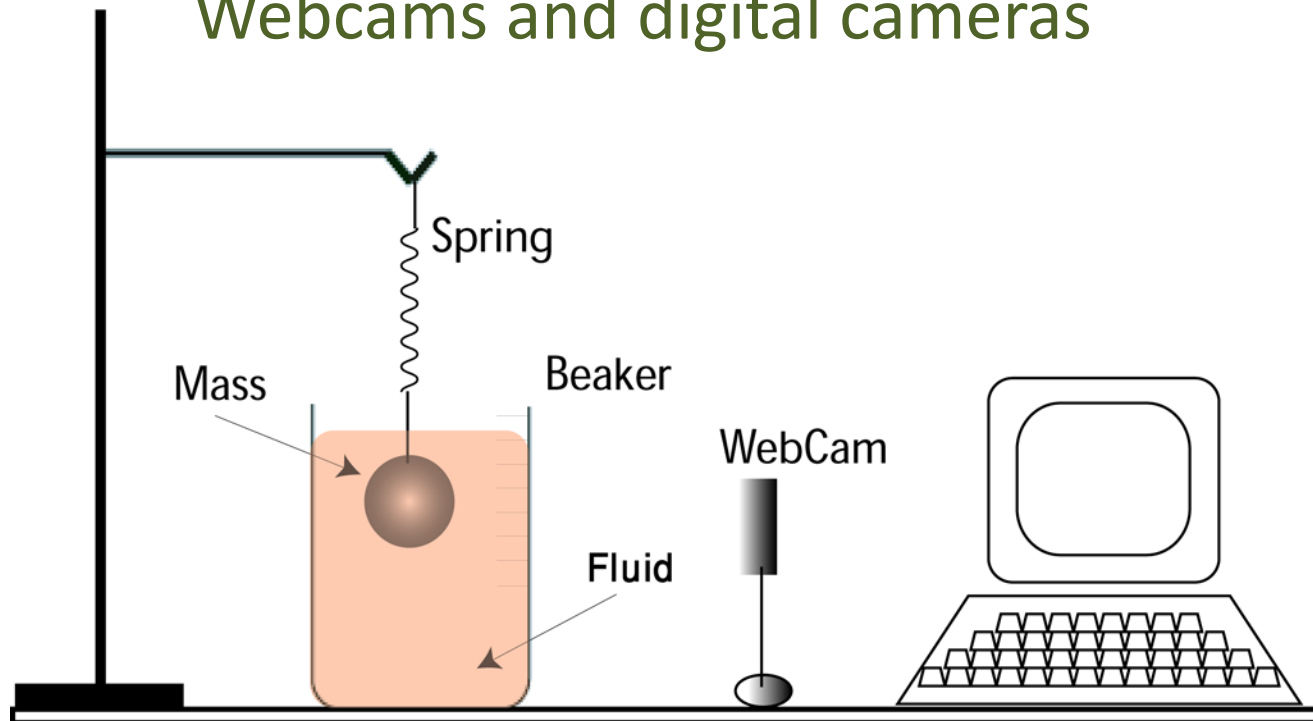
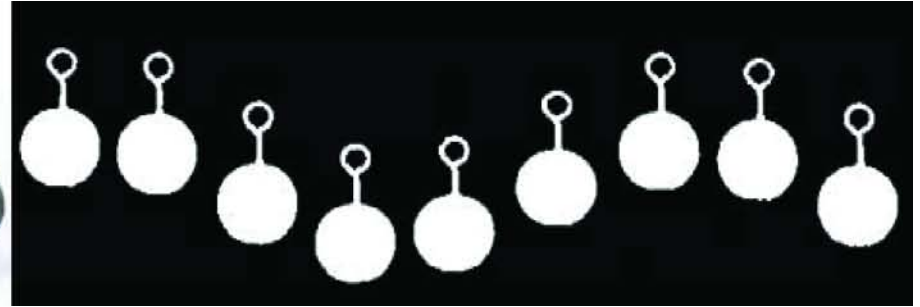
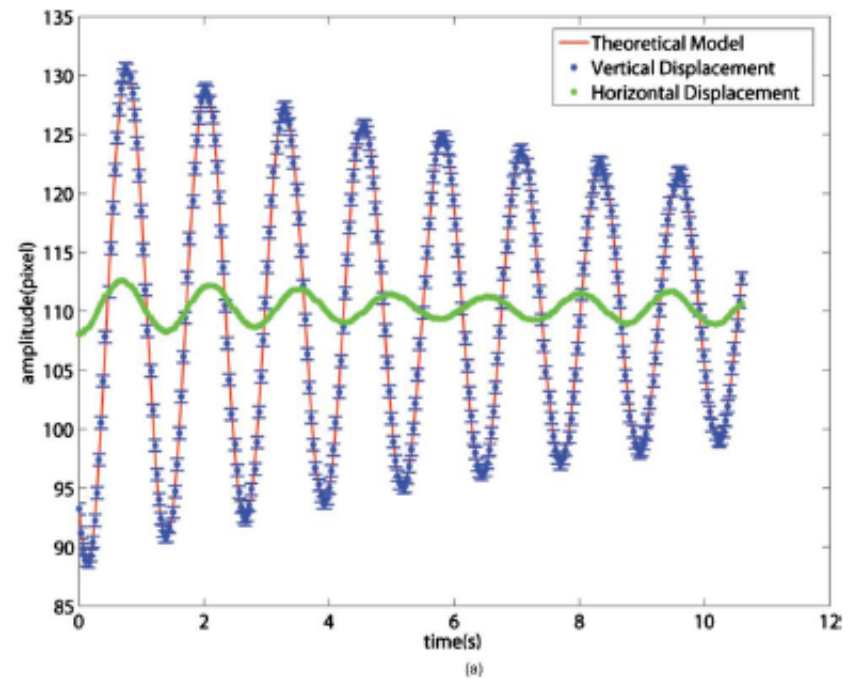
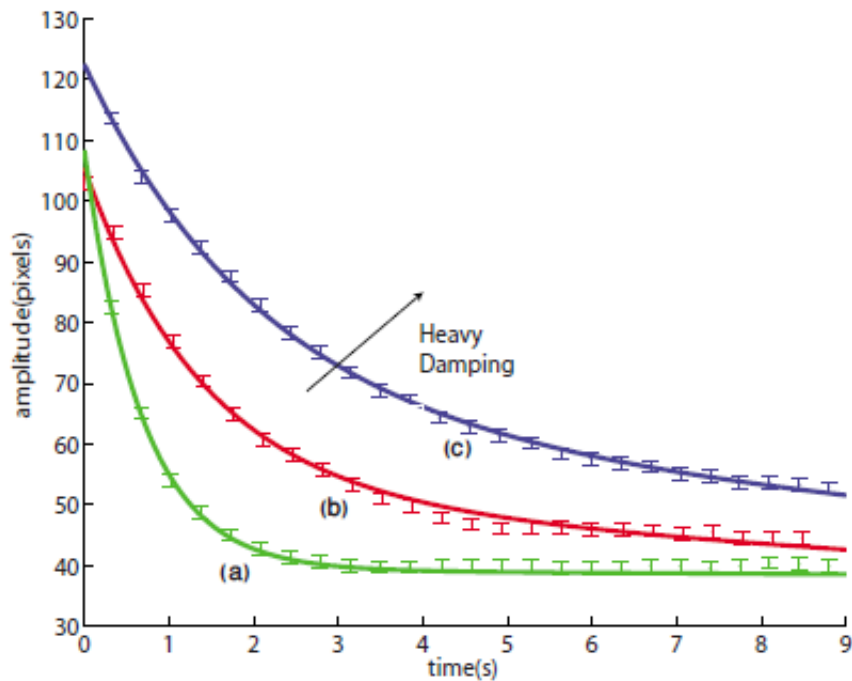
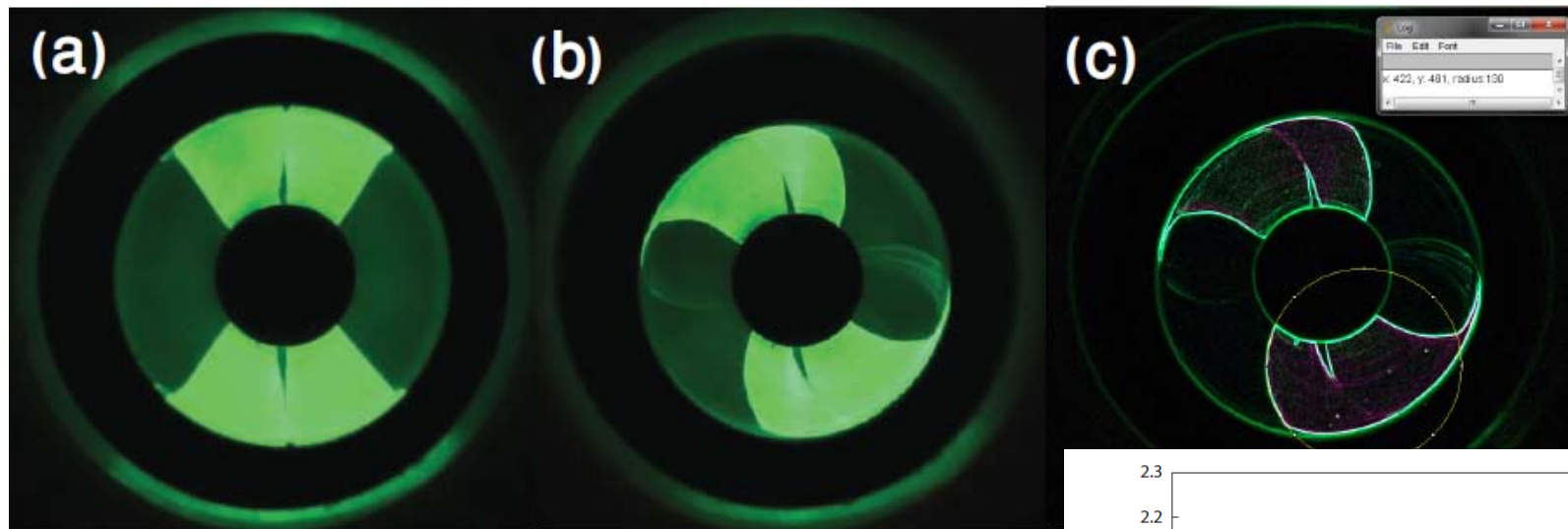
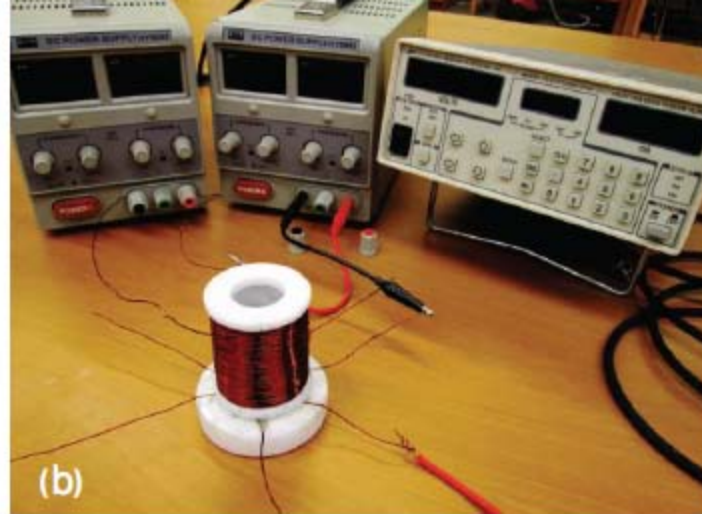
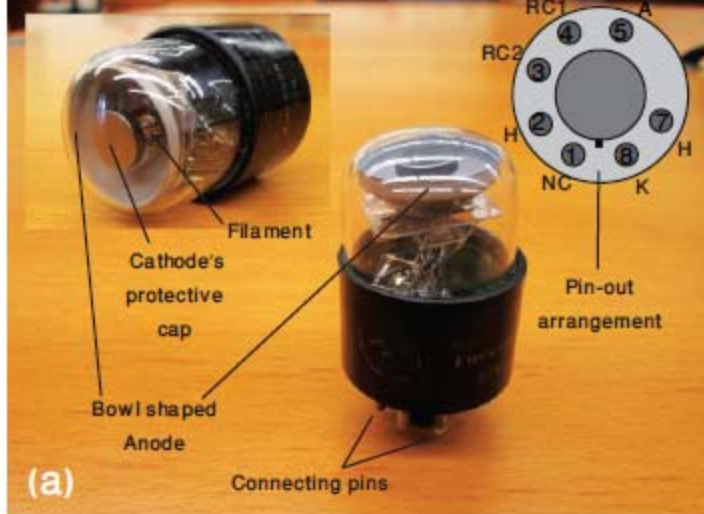


Image processing

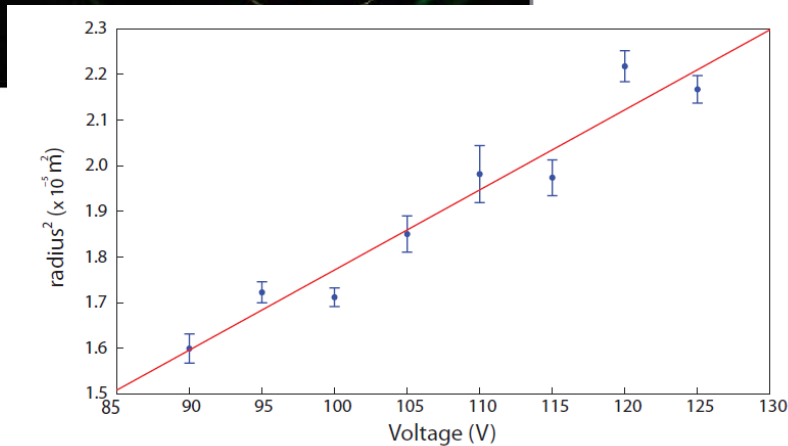


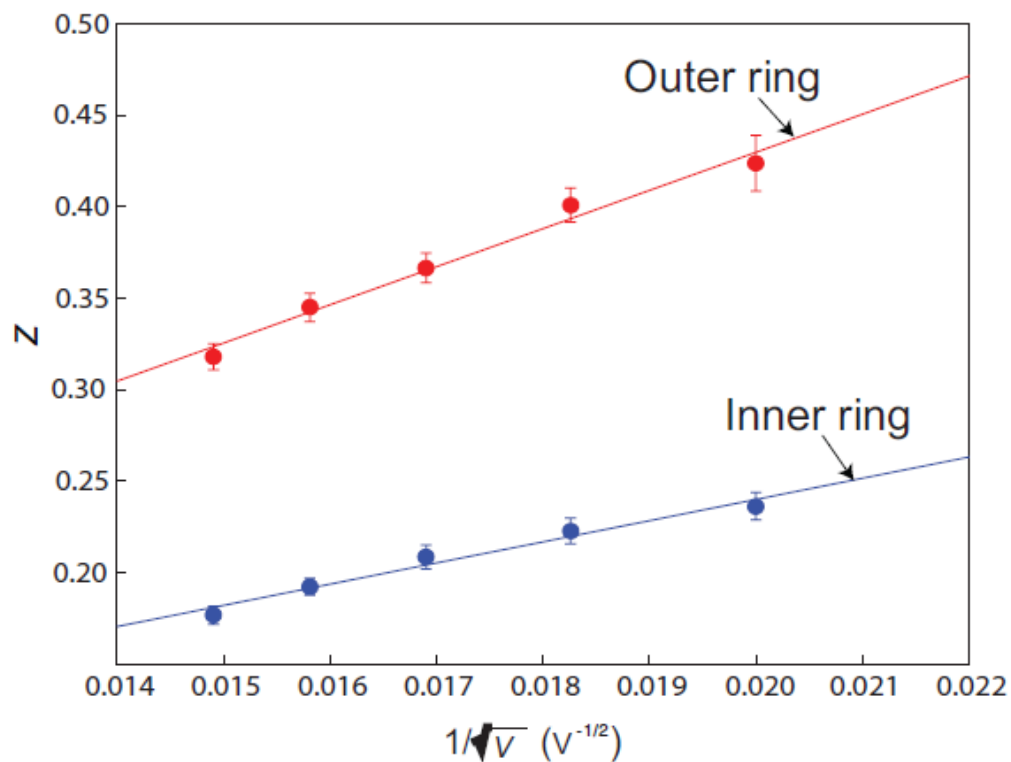
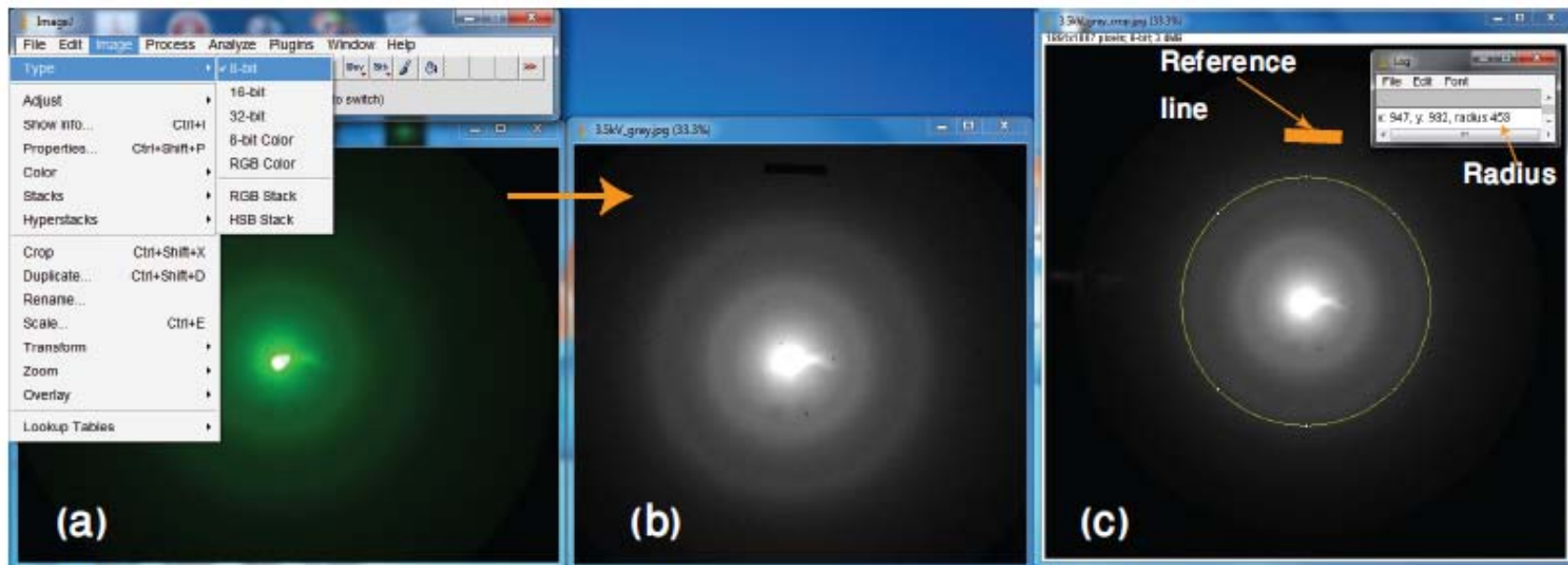
Exemplifying damped harmonic motion



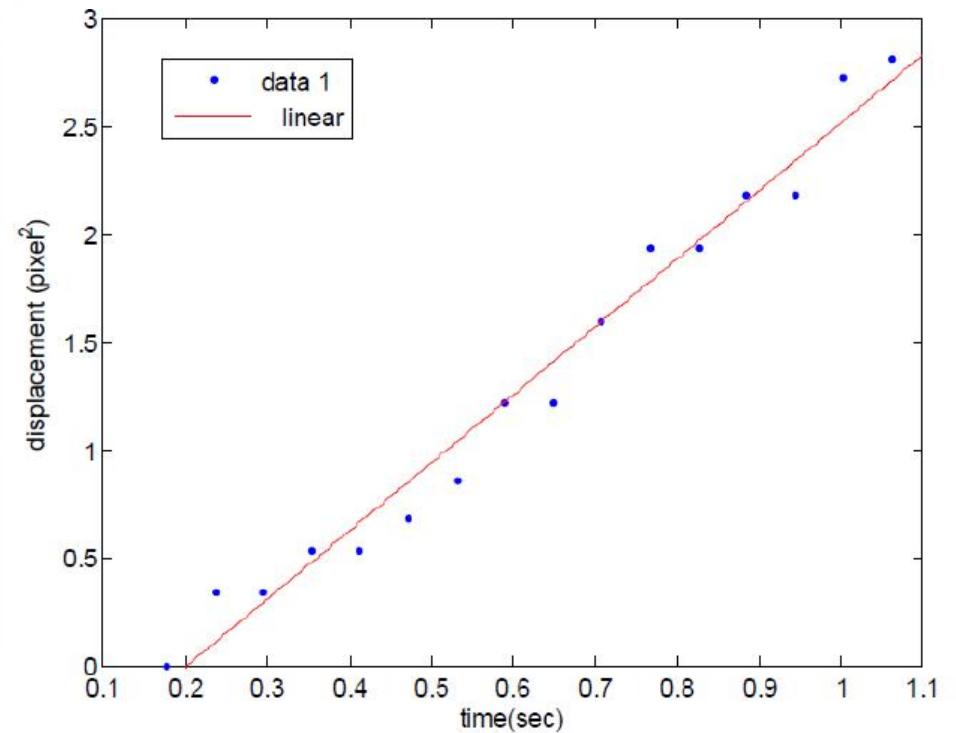
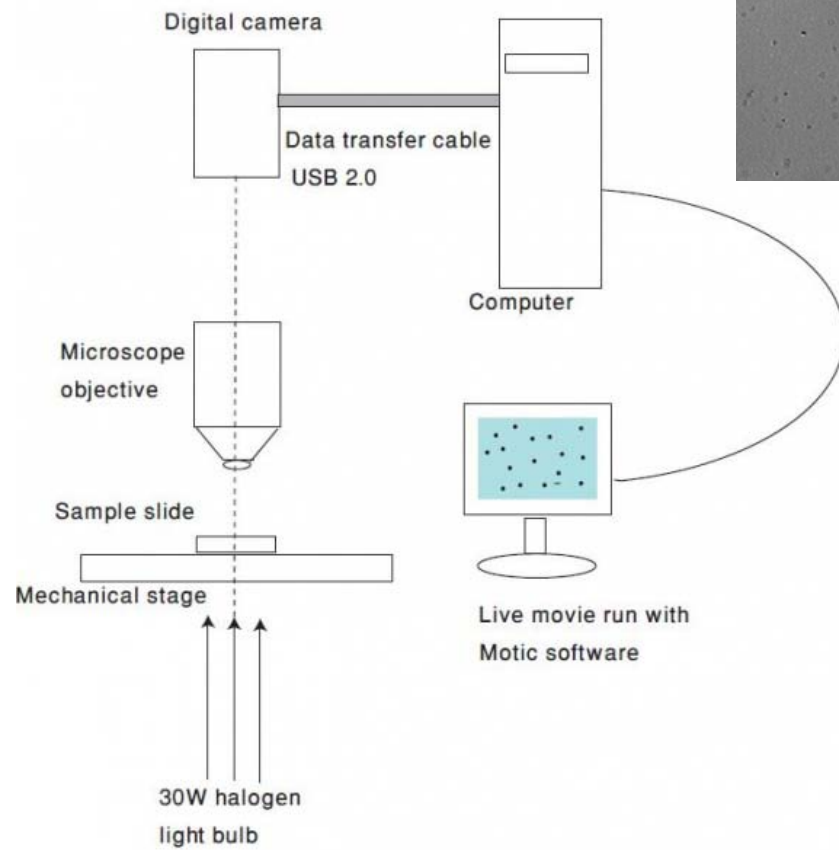
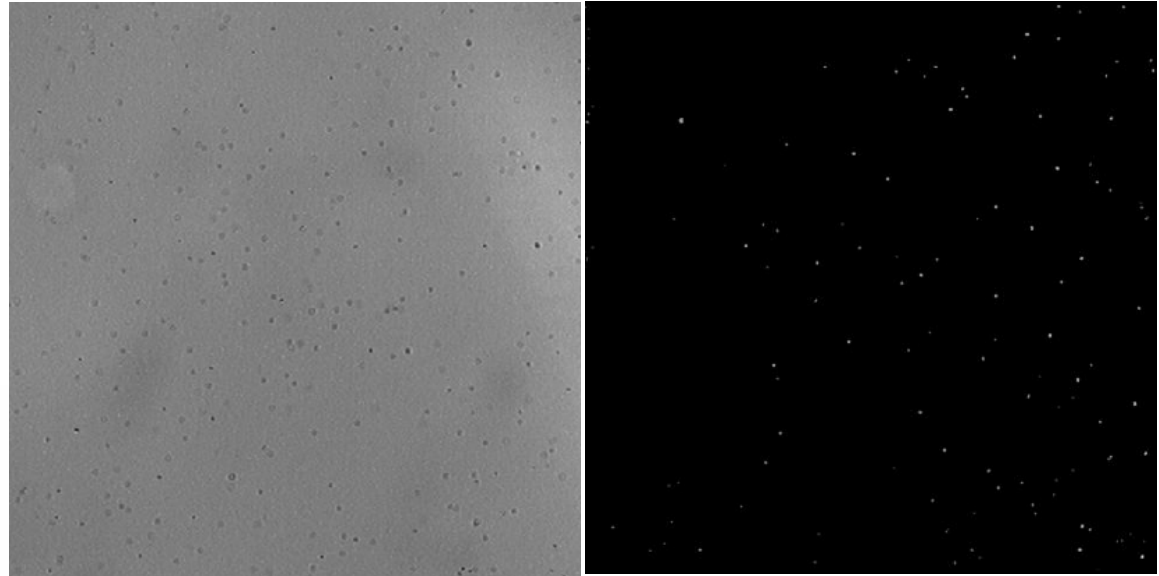


ImageJ: an open source paradigm for image processing

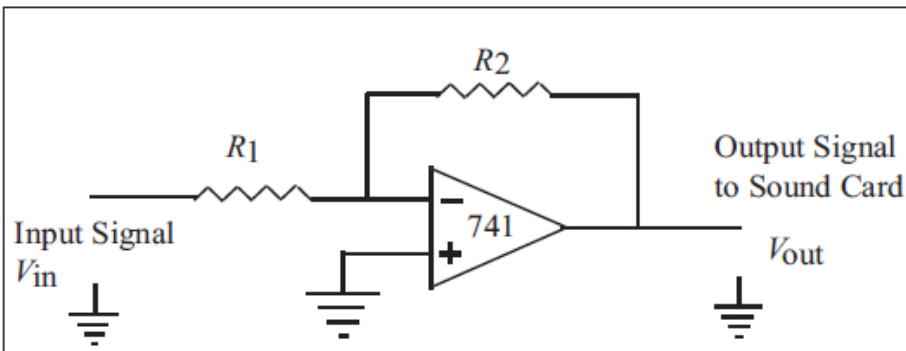
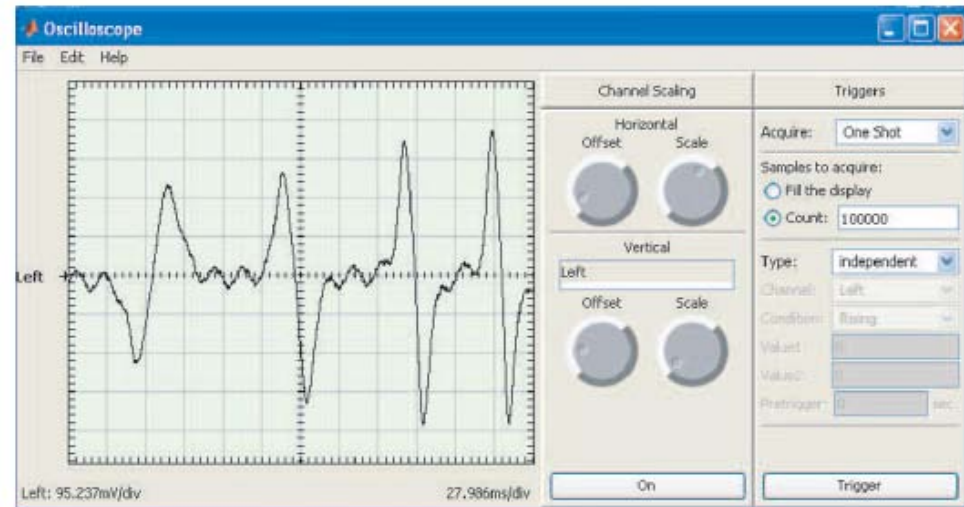
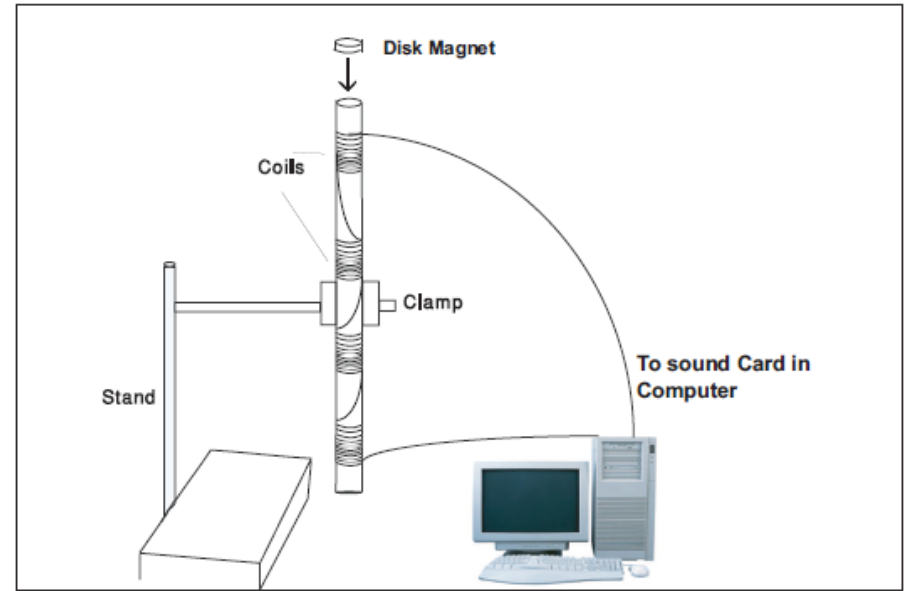
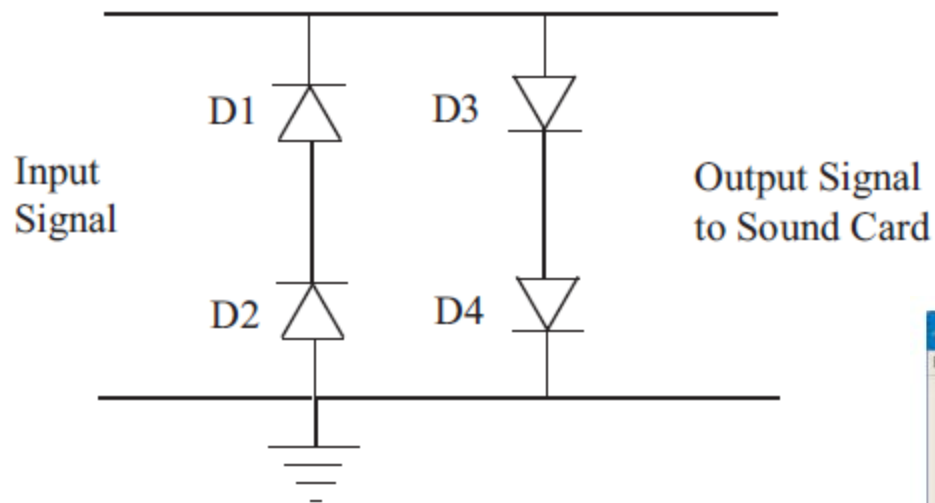
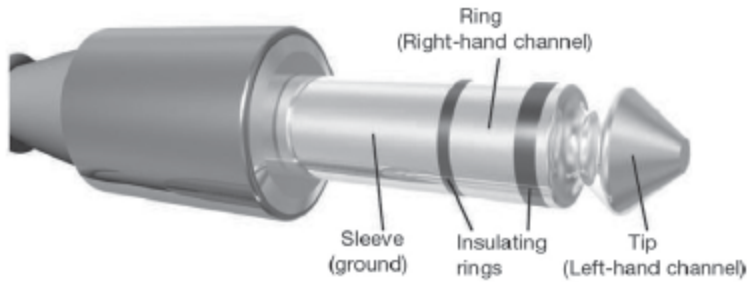




Video microscopy



Data acquisition with the sound card

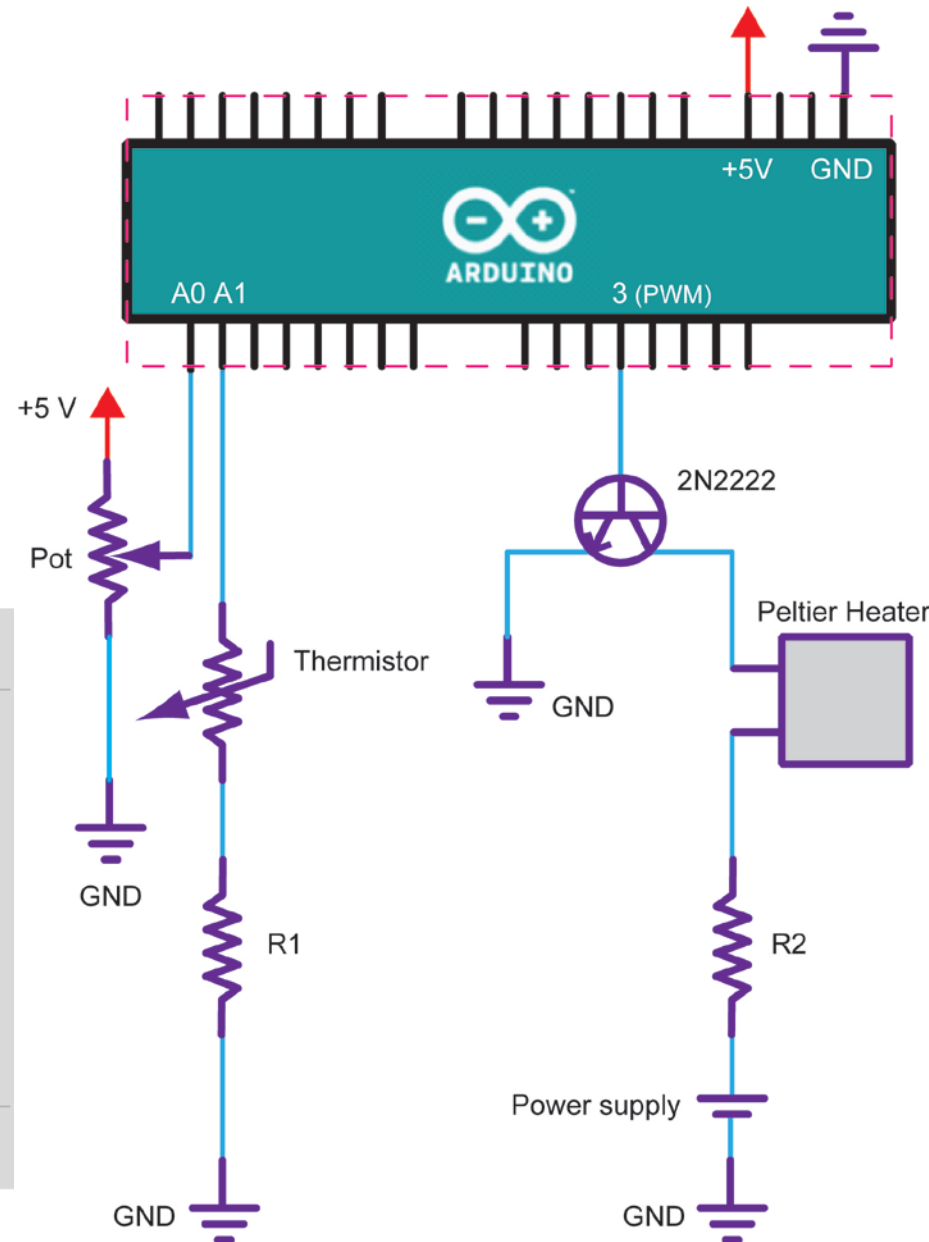


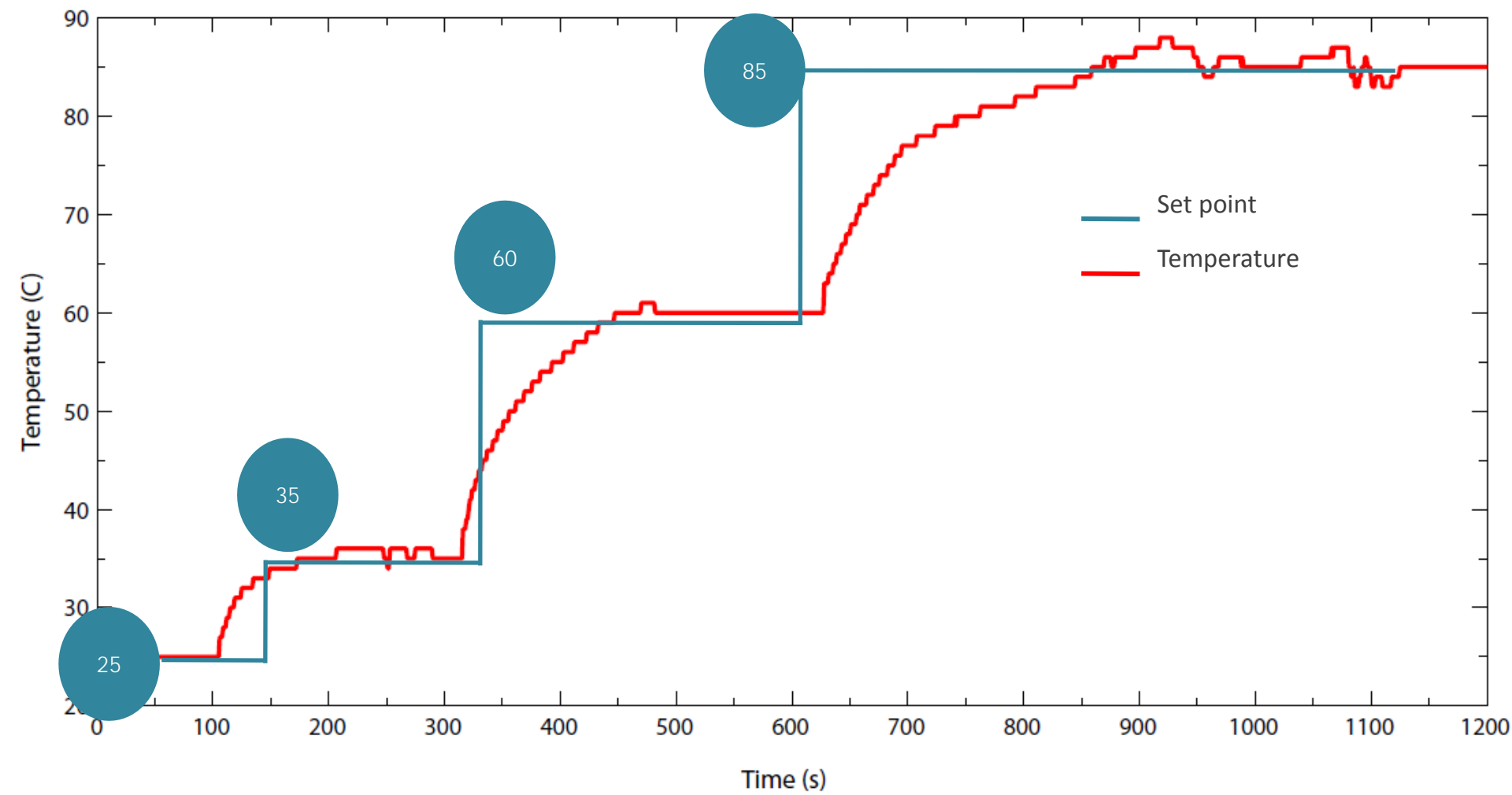
The emerging world of arduinos



- Open-source; software and hardware
- Big community; well documented and regular updates
- Based on existing language; Wiring (C-syntax)
- Easy to use; Bootloader interfaced through USB and simple user interface software
- Cheap (€15 - €30)

The diagram illustrates the connection of an Arduino Leonardo to a breadboard circuit. The breadboard contains a 555 timer IC, a 10k resistor, a 100k resistor, and a push button. The Arduino's digital pins are connected to the timer's control pins, and its power pins are connected to the breadboard's power rails. The push button is connected to a digital input pin.







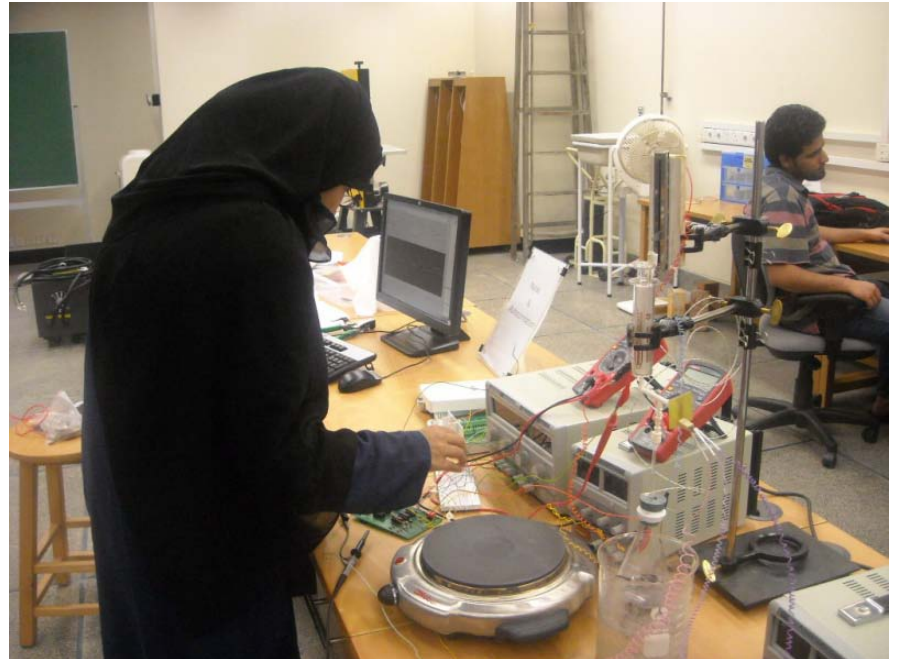
Centre for
Experimental Physics
Education (CEPE)

Goals of CEPE



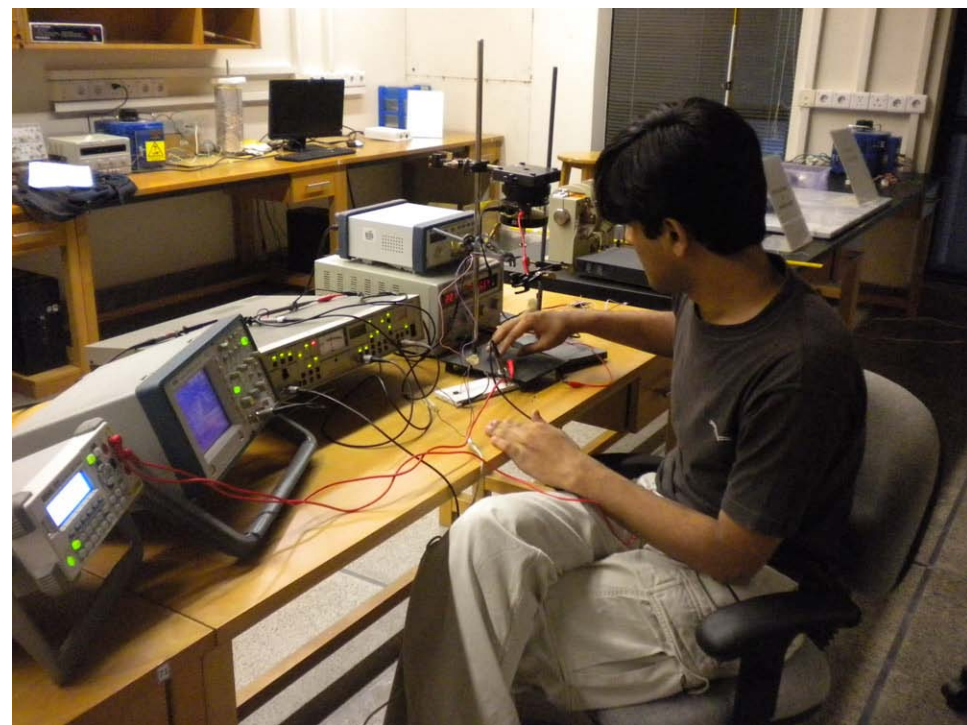
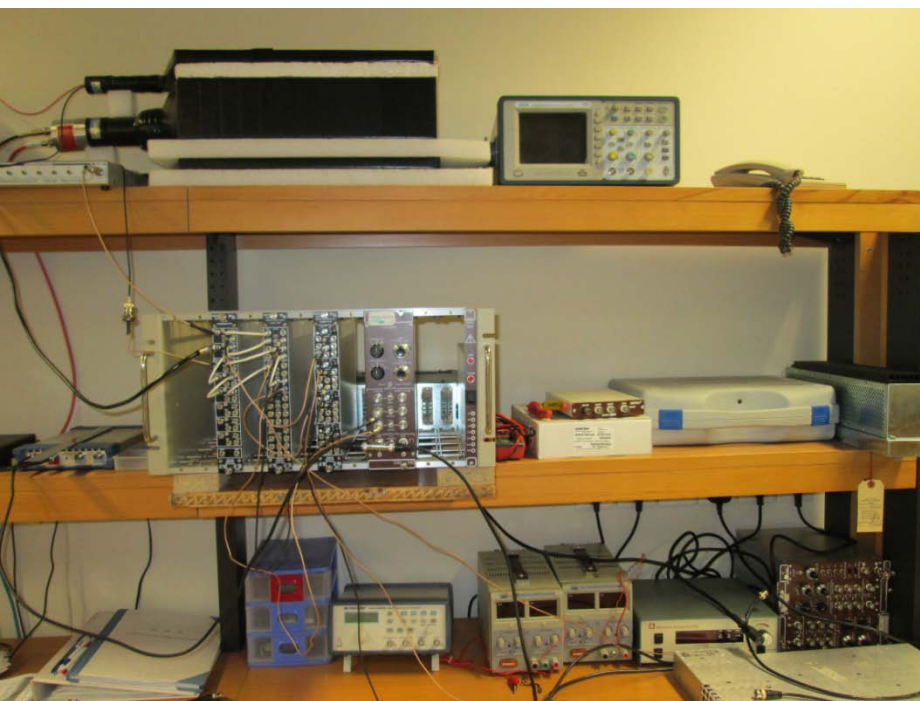
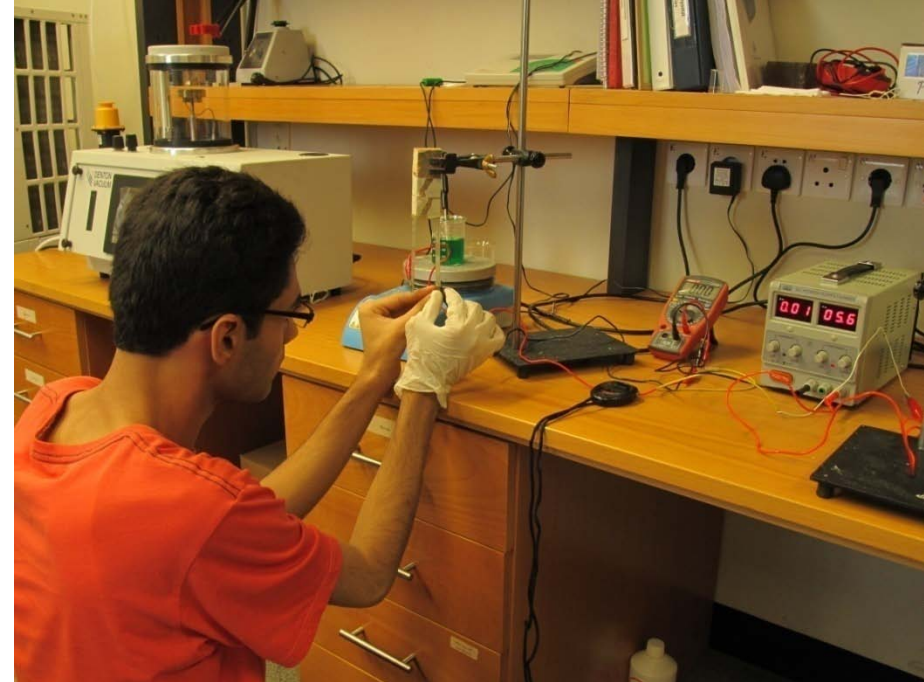
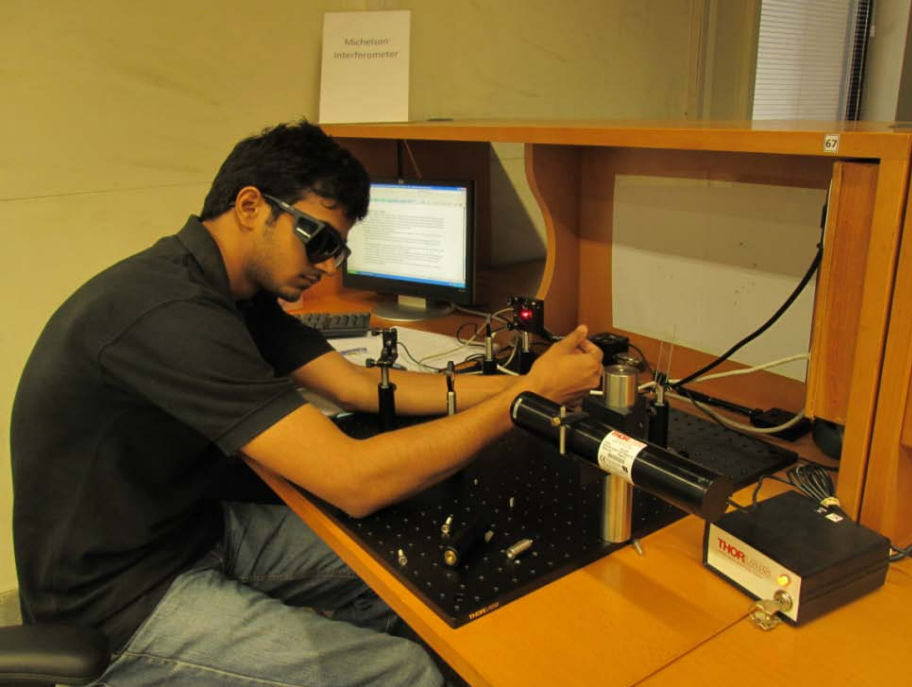
- Preparing an institutional and national platform for student-driven experimental research in physics.
- Indigenous development of experiments for the laboratory and demonstrations for the classroom.
- Training SSE students in world class experimental physics through required and optional lab courses.
- Sharing expertise, resources and training in physics education with sister institutions and organizations in the country and the region.

Image gallery









http://physlab.lums.edu.pk


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physlab.lums.edu.pk/index.php/Welcome_to_Experimental_Physics


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 - Optics (Fall Semester 2009)
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 - Lab-I (PHY 100)
 - Lab-II (PHY 300)
 - Lab-III (PHY 310)
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physlab.lums.edu.pk/index.php/List_of_Experiments



- The summer research program 2013 in the Physlab showcases exciting work done by students, ranging from making superconductors to detecting muons, erasing and recovering quantum information to electrodepositing films using novel techniques.



- Dr. Sabieh Anwar's course on Modern Physics concludes. The course is now being replicated at the DHA Suffa University.
- Physics Department collaborates with Centre for Advanced Studies in Mathematics (CASM) to organize a National Workshop on Mathematical Aspects of Quantum Information Science.
- Hafiz Rizwan receives training in vacuum science and technology at the NINVEST (National Institute of Vacuum Science and Technology), National Centre for Physics (25 to 29 March 2013).
- The Second National Lab Immersion Program 2013 was organized at the IBA, Sukkur between 12 and 13 January 2013. Ali hasan, Junaid Alam and Dr. Muhammad Sabieh Anwar traveled to Sukkur for this purpose. The target of this particular workshop, which is promised to take place twice a year in different locations in Pakistan, are Universities and community colleges in the



ice. The objective is to introduce participants to low-cost and modern experimental and teaching practices in the physics laboratory, especially at the higher secondary and degree

Acknowledgments

- Amrozia Shaheen
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- Muhammad Yousaf
- Asma Khalid
- Hasaan Majeed
- Sohaib Shamim
- Dr. Shahid Ramay
- Afaq Piracha
- Dr. Shahid Atiq