Developing a physics laboratory in the developing world

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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.”

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
LAB-I

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.
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
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:
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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

Diagram showing the components of a video microscopy setup:
- Digital camera
- Data transfer cable (USB 2.0)
- Computer
- Microscope objective
- Sample slide
- Mechanical stage
- 30W halogen light bulb

Graph showing displacement over time with a linear fit.
Data acquisition with the sound card

[Diagram of a sound card with connections and components]

[Diagram of a circuit with diodes and resistors]

[Diagram of an oscilloscope showing waveforms]

[Diagram of a magnetic coil and stand with a computer interface]
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)
Arduino in practice!
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.
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 OHA Sufia 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 Rezwan receives training in vacuum science and technology at the NINVAST (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 country. 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 levels.
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