

ADVANCED LABORATORY COURSE

**John Essick
Reed College**

OUTLINE:

- What is the Advanced Laboratory?
- Funding and Hot Topics
- ALPhA

VARIOUS APPROACHES TO ADVANCED LAB

Freshman

Intro Physics
with Lab

Intro Physics
With Lab

Sophomore

Intro Physics

Intro Physics

Junior/Senior

Classical Mechanics
Electrodynamics

Quantum Mechanics
Thermal Physics

VARIOUS APPROACHES TO ADVANCED LAB

Freshman

Intro Physics
with Lab

Intro Physics
With Lab

Sophomore

Intro Physics

Intro Physics
Modern Physics Lab

Junior/Senior

Classical Mechanics

Quantum Mechanics

Electrodynamics

Thermal Physics

Electronics Course

VARIOUS APPROACHES TO ADVANCED LAB

Freshman

Intro Physics
with Lab

Intro Physics
With Lab

Sophomore

Intro Physics

Intro Physics

Junior/Senior

Classical Mechanics
Electrodynamics

Quantum Mechanics
Thermal Physics

Specialty Course
with Lab
(e.g., Optics)

VARIOUS APPROACHES TO ADVANCED LAB

Freshman

Intro Physics
with Lab

Intro Physics
With Lab

Sophomore

Intro Physics

Intro Physics

Junior/Senior

Classical Mechanics

Quantum Mechanics

Electrodynamics

Thermal Physics

Independent Project
Course

VARIOUS APPROACHES TO ADVANCED LAB

Freshman

Intro Physics
with Lab

Intro Physics
With Lab

Sophomore

Intro Physics

Intro Physics

Junior/Senior

Classical Mechanics
Electrodynamics

Quantum Mechanics
Thermal Physics

Short Internship
in Research Lab

VARIOUS APPROACHES TO ADVANCED LAB

Freshman

Intro Physics
with Lab

Intro Physics
With Lab

Sophomore

Intro Physics

Intro Physics

Junior/Senior

Classical Mechanics
Electrodynamics

Quantum Mechanics
Thermal Physics

Lab Course with
Guided and
Independent
Projects

GOAL: TEACH BASIC RESEARCH SKILLS

PHYSICAL UNDERSTANDING

Apply Classroom Theory
Background Literature Searches
Consultation With Experts
Adequate Level of Precision
Range of an Approximation
Suppression of Competing Effects

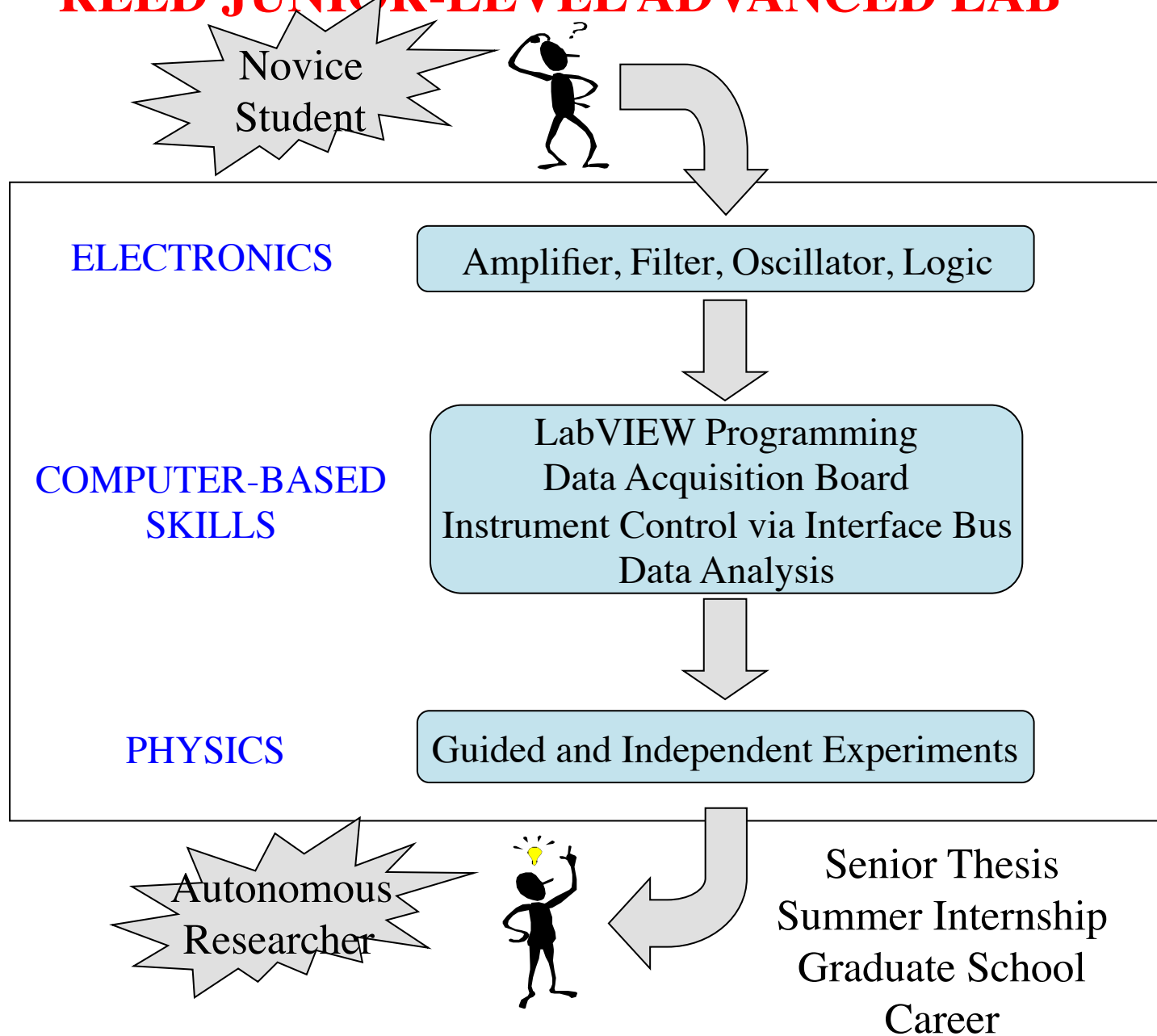
DATA-TAKING SKILLS

Electronics
Computer-Assisted Data Acquisition
Optics
Vacuum Technology
Data Analysis Techniques
Design of Sophisticated Instrumentation
Patience
Consistency Checking

RESPONSIBILITY TO THE COMMUNITY

Outside Interest In Results
Benefit Of Peer Review
Honest, Timely, Concise Report of Results

REED JUNIOR-LEVEL ADVANCED LAB



SPRING-SEMESTER PHYSICS EXPERIMENTS

Guided Experiments:

- Optical Bandgap of Semiconductor (Monochromator)
- Doppler-Free Saturated Absorption Spectroscopy (Laser Diode)
- Temperature Dependence of Diode's Saturation Current (Cryostat)
- Isotope Shift of Balmer Series in Hydrogen (Spectrometer)
- Mass of Cosmic Ray Muon (Fast-Timing Electronics)
- Fabrication of Fullerenes (Materials Fabrication)
- Proof of Existence of Photons (Single-Photon Detection)

SPRING-SEMESTER PHYSICS EXPERIMENTS

Independent Projects:

- High-Temperature Superconductor
- Chaotic Electrical Circuit
- Raman Spectroscopy
- Quantized Conductance in Nanowire
- Quantum-Dot Photoluminescence
- Period of Jupiter's Moons
- Optical Tweezers

FUNDING ADVANCED LAB DEVELOPMENT

Institutional Sources:

- Departmental Budget Line-Item
- Development Office
- Alumni Donations
- Local Industry Donations

External Sources:

- Foundations (e.g., Keck)
- NSF (Broader Impact, Dissemination)

HOT TOPICS IN ADVANCED LAB DEVELOPMENT

Quantum Optics Experiments:

Existence of Photon
Single-Photon Interference
Entanglement and Quantum Eraser
Bell's Inequality

Computer-Based Data Acquisition:

LabVIEW
MATLAB
Arduino

Low-Cost Electronics:

Field Programmable Gate Array (FPGA)
Microelectromechanical Systems (MEMS)
Wireless Communication

ADVANCED LABORATORY PHYSICS ASSOCIATION (ALPhA)

Purpose:

Promote Advanced Experimental Physics Instruction

Organization:

- Founded 2007
- 250 College and University Advanced Laboratory Developers
- Web Page – advlab.org
- \$30 Membership Fee

Programs:

- Laboratory Immersions
- Conference on Laboratory Instruction Beyond the First Year (BFY)
- Discounted Equipment

LABORATORY IMMERSIONS PROGRAM

Purpose:

Advanced Lab Faculty and Staff Development

Format:

- Taught at Volunteer Mentor's Institution
- Two- or Three-Day Training on One Advanced Lab Experiment
- Cost – \$350 Registration (includes meals) plus Travel Expenses

Note:

Mentor Can Use For Dissemination Component of NSF Grant

LABORATORY IMMERSIONS PROGRAM

ALPhA's
Laboratory
Immersion
Summer 2015



Learn a
NEW ADVANCED LAB EXPERIMENT
well
TEACH WITH CONFIDENCE!
**EQUIPMENT GRANTS
NOW AVAILABLE!**

June 2-4 Harvey Mudd College (CA) <ul style="list-style-type: none">• Single Photon/Entangled Photon Experiments	June 2-4 Colgate University (NY) <ul style="list-style-type: none">• Experiments on Photon Quantum Mechanics
June 9-11 Univ. of Tennessee (TN) <ul style="list-style-type: none">• X-ray Diffraction and Compton Scattering	June 15-17 CSU - Chico (CA) <ul style="list-style-type: none">• Arduinos in the Advanced Lab
July 7-9 Princeton Plasma Physics Lab (NJ) <ul style="list-style-type: none">• Low Cost Plasma Physics: Paschen Curve• Low Cost Plasma Physics: Spectroscopy• Low Cost Plasma Physics: Electron Temperature	June 24-26 Univ. of Florida (FL) <ul style="list-style-type: none">• Optical Trapping for Biological Physics• Fluorescence Correlation Spectroscopy
July 8-10 Miami University (OH) <ul style="list-style-type: none">• Arduinos for the Advanced Lab	July 8-10 Bethel University (MN) <ul style="list-style-type: none">• FPGA Exercises in the Advanced Lab• Ultrafast Optics - Frequency Comb• Nano-Plasmonics and Surface-Enhanced Spectroscopy
August 1-3 Univ. of Michigan (MI) <ul style="list-style-type: none">• Galactic Rotation and Evidence for Dark Matter• Faraday rotation in optical media• Measuring the Cosmic Microwave Background• $e^+ - e^-$ Pair Production	August 5-7 Caltech (CA) <ul style="list-style-type: none">• Electrodynamical Ion Trapping• Precision Measurements Using Interferometry• Magneto-mechanical Harmonic Oscillator



LEARN MORE AT:
WWW.ADVLAB.ORG

Advanced Laboratory
Physics Association

BFY CONFERENCE

Purpose:

Community Building for Advanced Lab Developers

Format:

- 2.5-Day Conference Once Every Three Years
- Limited to 150 Participants
- 12 40-Minute Workshops on Different Advanced Lab Experiments
- Plenaries and Breakout Sessions on Advanced Lab Topics
- Poster Session
- \$199 Registration Fee, Includes All Meals

BFY CONFERENCE

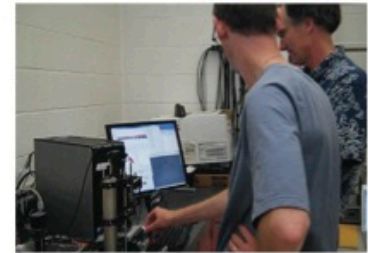
The Second Conference on

Laboratory Instruction Beyond the First Year of College

University of Maryland

July 22 - 24, 2015

WWW.ADVLAB.ORG



DISCOUNTED EQUIPMENT

Purpose:

Support Implementation of Laboratory Immersions Experiments

Quantum Optics Experiments = Most Popular Immersion:

- Single-Photon Detectors are Most Expensive Component
- ALPhA Sells Detectors for \$1430 Each (About Half Retail Price)
- Total Experiment Cost is about \$20k



DISCOUNTED EQUIPMENT

Jonathan F. Reichert Foundation ALPhA Immersions Support:

For Immersion Attendee,
up to 40% of Cost of Immersion Experiment Equipment
(\$7,500 Maximum)