The Abdus Salam
International Centre for Theoretical Physics

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Educational, Scientific and
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Meeting of Modern Science and School Physics: College for School Teachers of Physics in ICTP

27 April - 3 May, 2011

Computer based tools for active learning in the introductory physics course

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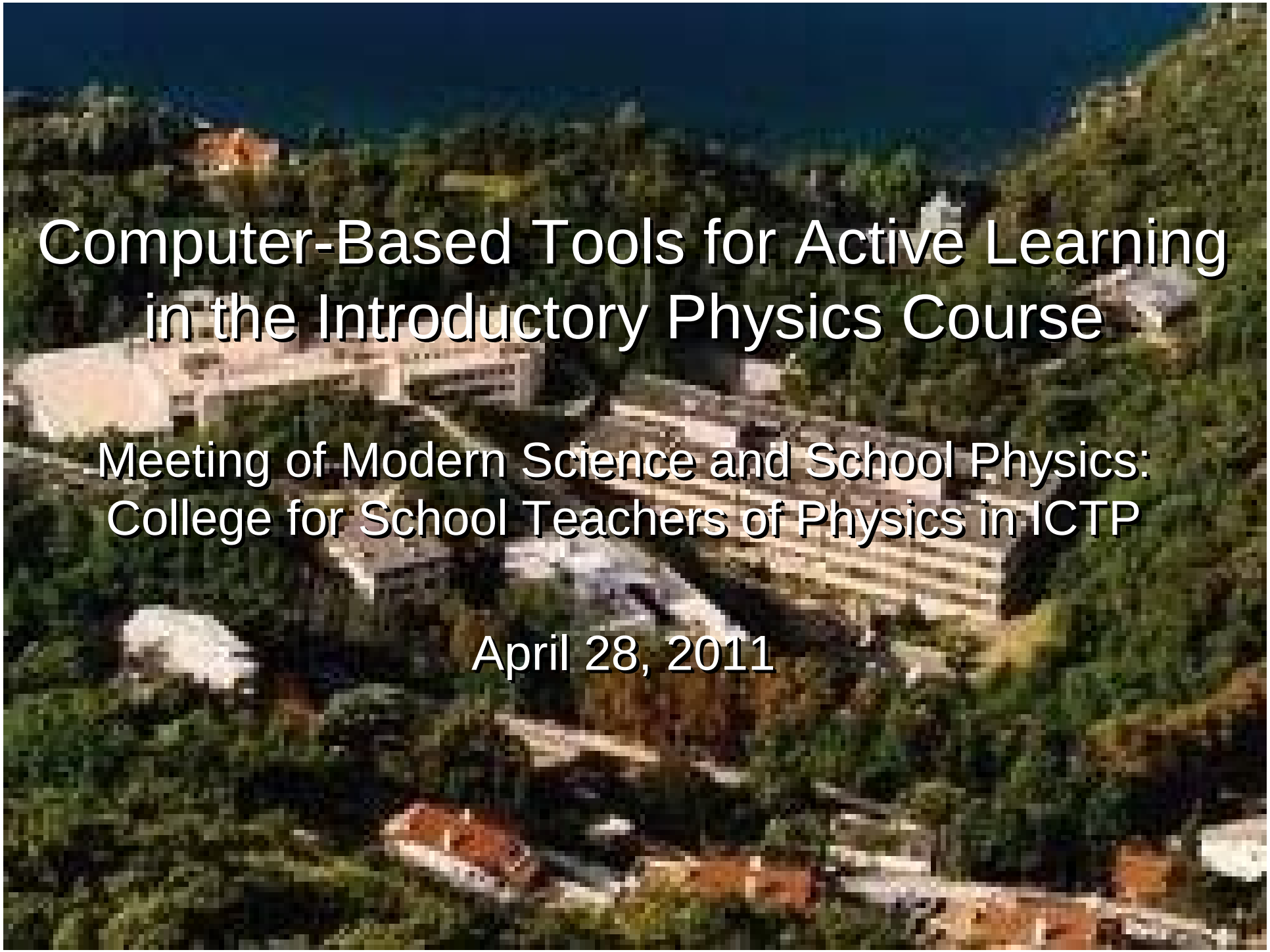


Computer-Based Tools for Active Learning in the Introductory Physics Course

Meeting of Modern Science and School Physics: College for School Teachers of Physics in ICTP

April 28, 2011

RealTime Physics:
Active Learning Labs

RealTime Physics Labs

A series of lab modules that use computer-based tools to help students develop important physics concepts while acquiring vital laboratory skills. Besides using computer probes, computers are used for basic mathematical modeling, data analysis and some simulations. *RTP* labs use the learning cycle of prediction, observation and comparison, and have been demonstrated to enhance student learning of physics concepts.

Goals of *RealTime Physics*

1. To help students acquire an understanding of a set of related physics concepts.
2. To provide students with direct experience of the physical world by using MBL tools for real-time data collection, display and analysis.
3. To enhance traditional laboratory skills.
4. To reinforce topics covered in lectures and readings using a combination of conceptual activities and quantitative experiments.

There are four *RTP* modules:

Module 1: Mechanics

Module 2: Heat and Thermodynamics

Module 3: Electric Circuits (3rd Edition January, 2012, E & M)

Module 4: Light and Optics

1. Guide students to construct physical models based on observations of the physical world.
2. Labs are sequenced, and build upon previous knowledge. Students learn the essential concepts in an area of physics.
3. Fit within the traditional structure of the introductory course.
4. Include pre-lab preparation sheets and homework designed to reinforce concepts and skills.
5. Are compatible with most computer data acquisition systems.

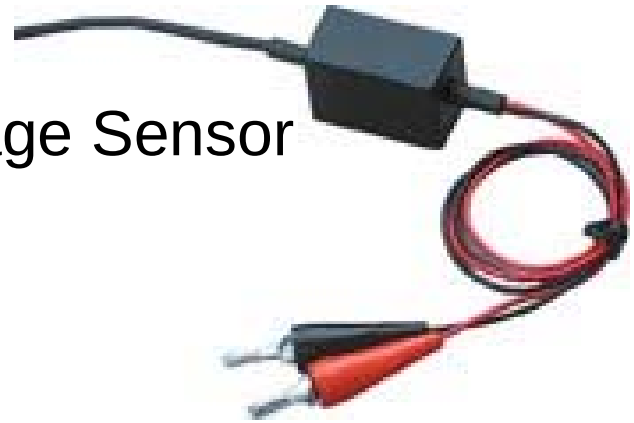
Examples from *RTP Electric Circuits* of Microcomputer-Based Sensors to Explore Electric Circuits

Student Difficulties in Understanding Electric Circuits, McDermott et. al.

- Failure to distinguish among concepts of current, potential difference, energy and power
- Lack of concrete experiences with real circuits
- Failure to understand the concept of a complete circuit
- Belief that direction of current and order of elements matter
- Belief that current is "used up" in a circuit
- Belief that the battery is a constant current source
- Failure to recognize that an ideal battery maintains a constant potential difference
- Difficulty in identifying series and parallel connections
- Tendency to focus on quantity rather than quality of elements or branches to determine resistance

Microcomputer-Based Lab Tools for Studying Circuits

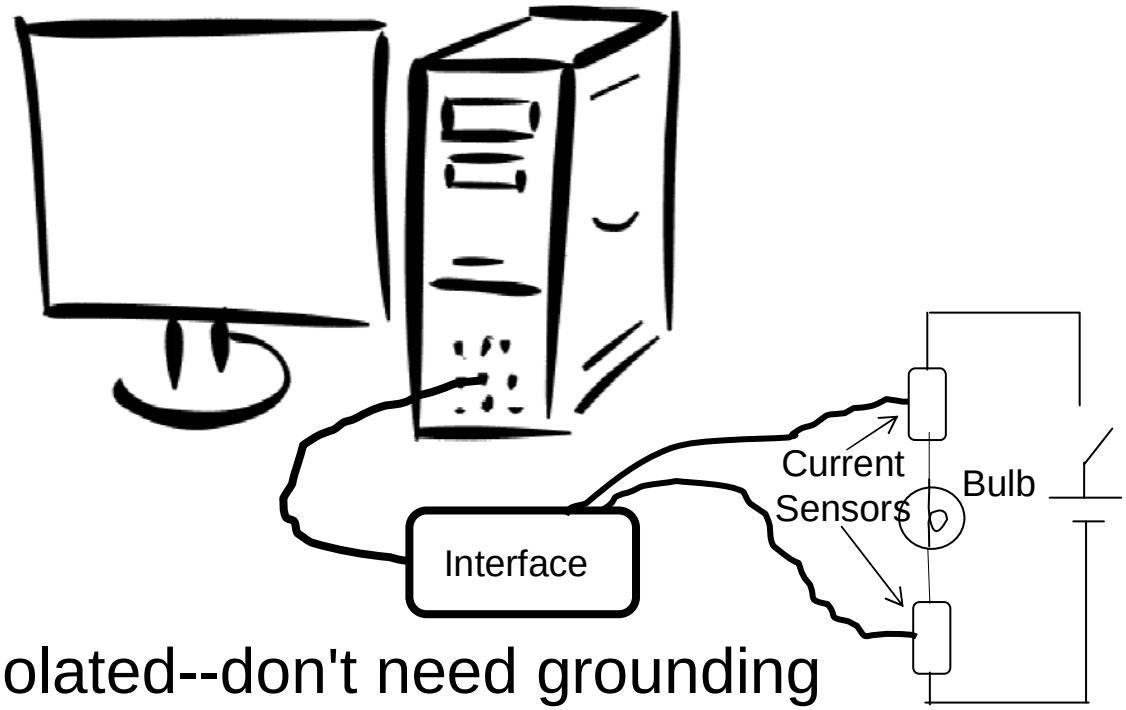
Current Sensor



Voltage Sensor

Interface

Current and Voltage Sensors



- Effectively isolated--don't need grounding
- Two sensors may be connected as voltage or current sensor at any location(s) in circuit
- Software identifies current/voltage probe
- Read currents to 600 mA, voltages to 6 V
- Graphs vs. time or vs. each other plotted in real time

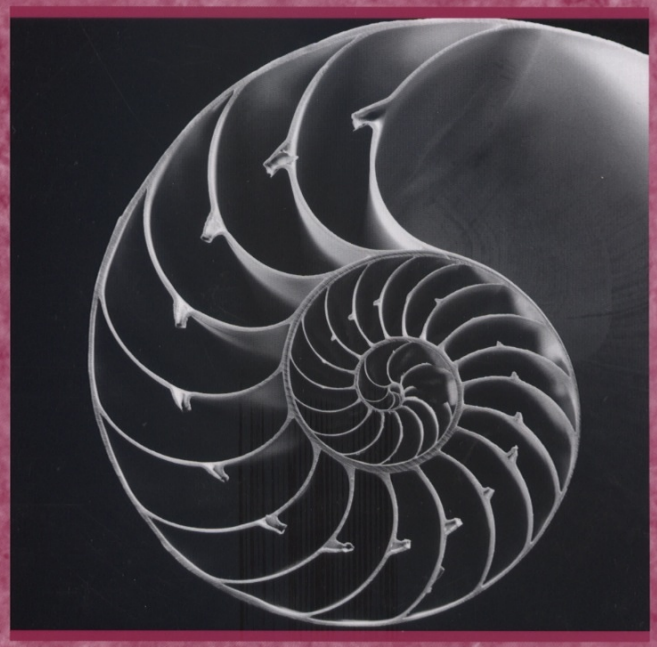
RealTime Physics Electric Circults
Curriculum Design

Batteries and bulbs approach with quantitative graphs of current and voltage.

Students observe brightness of bulbs and simultaneously see graphical histories of what is happening at two points in a circuit.

RealTime Physics
Active Learning Laboratories

MODULE 3
Electric Circuits



THE PHYSICS SUITE

DAVID R. SOKOLOFF
RONALD K. THORNTON
PRISCILLA W. LAWS

RTP Electric Circuits Contents

Lab 1: Batteries, Bulbs and Current

Lab 2: Current in Simple DC Circuits

Lab 3: Voltage in Simple DC Circuits and Ohm's Law

Lab 4: Kirchhoff's Circuit Laws

Lab 5**:** Introduction to Capacitors and RC Circuits

Lab 6: Introduction to Inductors and LR Circuits

Lab 7: Introduction to Time-Varying (AC) Signals

Lab 8: Introduction to AC Filters and Resonance

Coming January, 2012
RTP Electricity and Magnetism

OLD

Lab 1: Batteries, Bulbs and Current

Lab 2: Current in Simple DC Circuits

Lab 3: Voltage in Simple DC Circuits and Ohm's Law

Lab 4: Kirchhoff's Circuit Laws

Lab 5**:** Introduction to Capacitors and RC Circuits

Lab 6: Introduction to Inductors and LR Circuits

Lab 7: Introduction to Time-Varying (AC) Signals

Lab 8: Introduction to AC Filters and Resonance

New

Lab 1: Electric Charge, Force and Fields

Lab 2: Electric Fields and Gauss' Law

Lab 3: Electric and Gravitational Potential

Lab 4: Batteries, Bulbs and Current

Lab 5: Current in Simple DC Circuits

Lab 6: Voltage in Simple DC Circuits and Ohm's Law

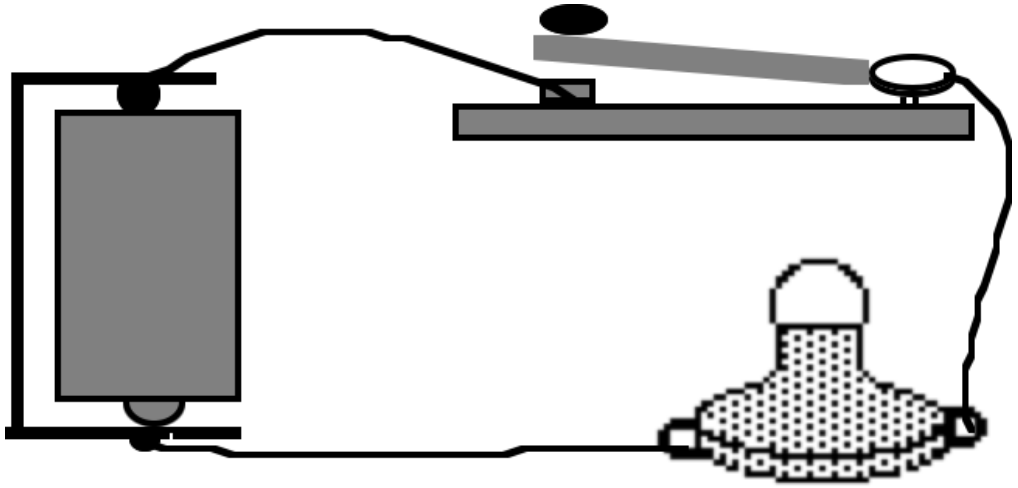
Lab 7: Kirchhoff's Circuit Laws

Lab 8: Introduction to Capacitors and RC Circuits

Lab 9: Magnetism

Lab 10: Electromagnetic Induction

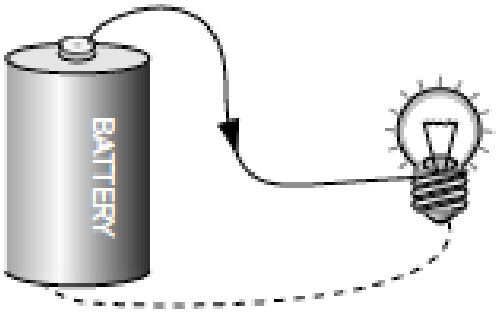
Lab 1, Activity 1-5



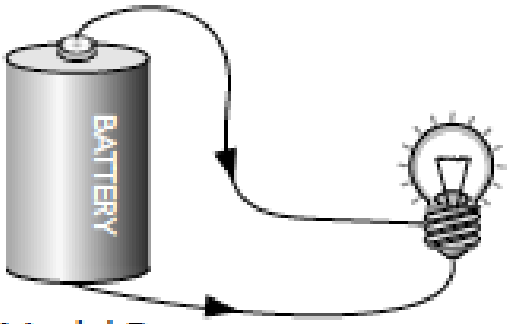
In the diagrams in Figure 1, below are shown several models for the current in this circuit that people often propose.

Prediction 1: Which model in Figure 1 do you think best describes the current through the bulb? After you make your own prediction, talk things over with your partners. Explain your reasoning.

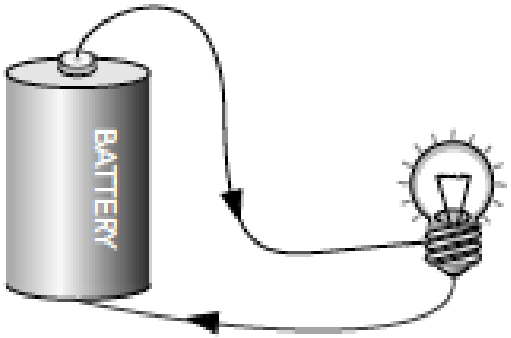
Figure 1: Four alternative models for current.



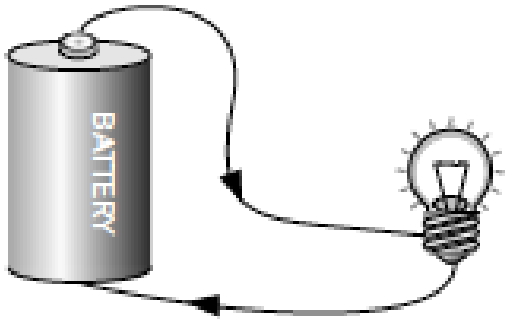
Model A
There will be no electric current left to flow in the bottom wire since the current is used up lighting the bulb.



Model B
The electric current will travel in a direction toward the bulb in both wires.

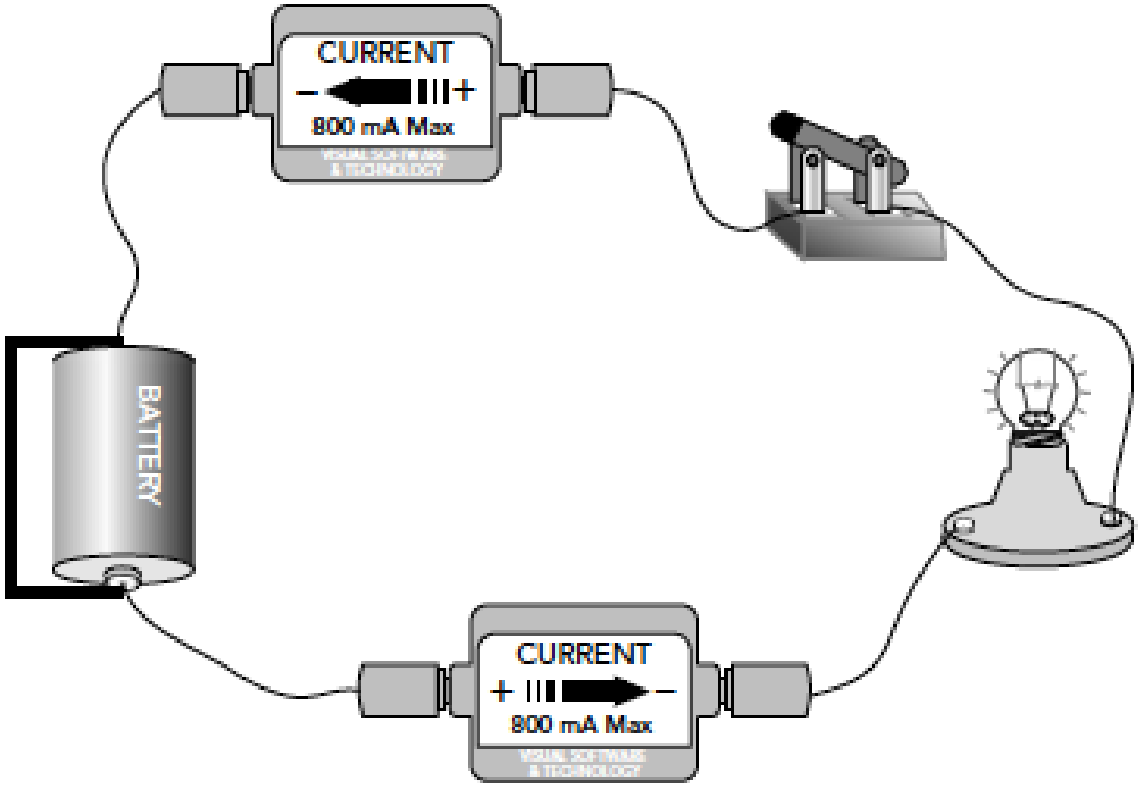


Model C
The direction of the current will be in the direction shown, but there will be less current in the return wire since some of the current is used up lighting the bulb.



Model D
The direction of the current will be as shown, and the magnitude will be the same in both wires.

Figure 2: Two current sensors are connected to measure the current flowing into the bulb and the current out of the bulb and into the terminal of the battery.



Prediction 2: Use Table 1-1 to describe how the readings of current sensor 1 and current sensor 2 in the circuit in Figure 2 would compare with each other for each of the current models described in Figure 1.

Table 1-1

	Probe	Positive, negative, or zero?	CP1 > CP2, CP1 < CP2, or CP1 = CP2?
Model A	CP1		
	CP2		
Model B	CP1		
	CP2		
Model C	CP1		
	CP2		
Model D	CP1		
	CP2		

Begin with this activity at the middle of page 9 in *RealTime Physics* Lab 1:

Batteries, Bulbs and Currents

Please behave as students (should)—really read the instructions, work through all the activities, make all the predictions and answer the questions!

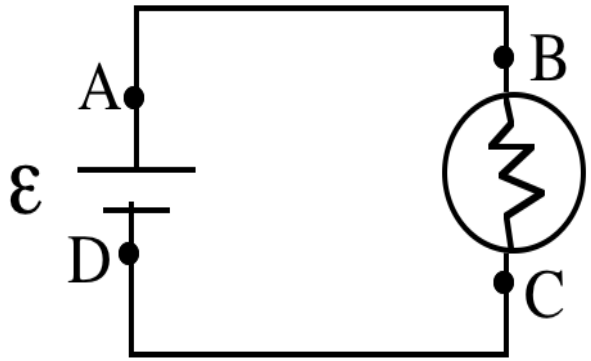
Do students learn concepts from *RealTime Physics* Labs?

The Electric Circuits Conceptual Evaluation (ECCE)

- Multiple choice questions based on previous research using open-ended assessments and interviews.
- Questions asked in a number of different forms and contexts.
- Makes possible tracking of student progress and persistence of learning during a course.
- Makes possible comparison of varied student populations from a variety of institution.

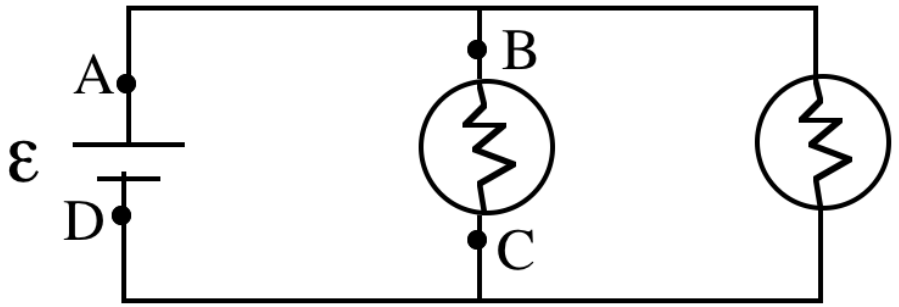
Sample Questions from the ECCE

1. A bulb and a battery are connected as shown below. Which is true about the current at various points in this circuit?



A. The current is largest at A.
B. The current is largest at B.
C. The current is largest at C.
D. The current is largest at D.
E. The current is the same everywhere.
F. The current is the same between A and B and smaller than between C and D.
G. The current is the same between A and B and larger than between C and D.
H. The current is the same everywhere except in the bulb.
I. The current is the same everywhere except in the battery.
J. None of these is true.

For Questions 2-3, a second identical bulb is added to the circuit in Question 1, as shown to the right.



2. Compare the current at A now to the current at A before with only one bulb.

A. The current at A is now twice as large as before.

B. The current at A is now larger than before but not twice as large.

C. The current at A is the same as before.

D. The current at A is now half as large as before.

E. The current at A is now smaller than before but not half as large.

J. None of these is correct.

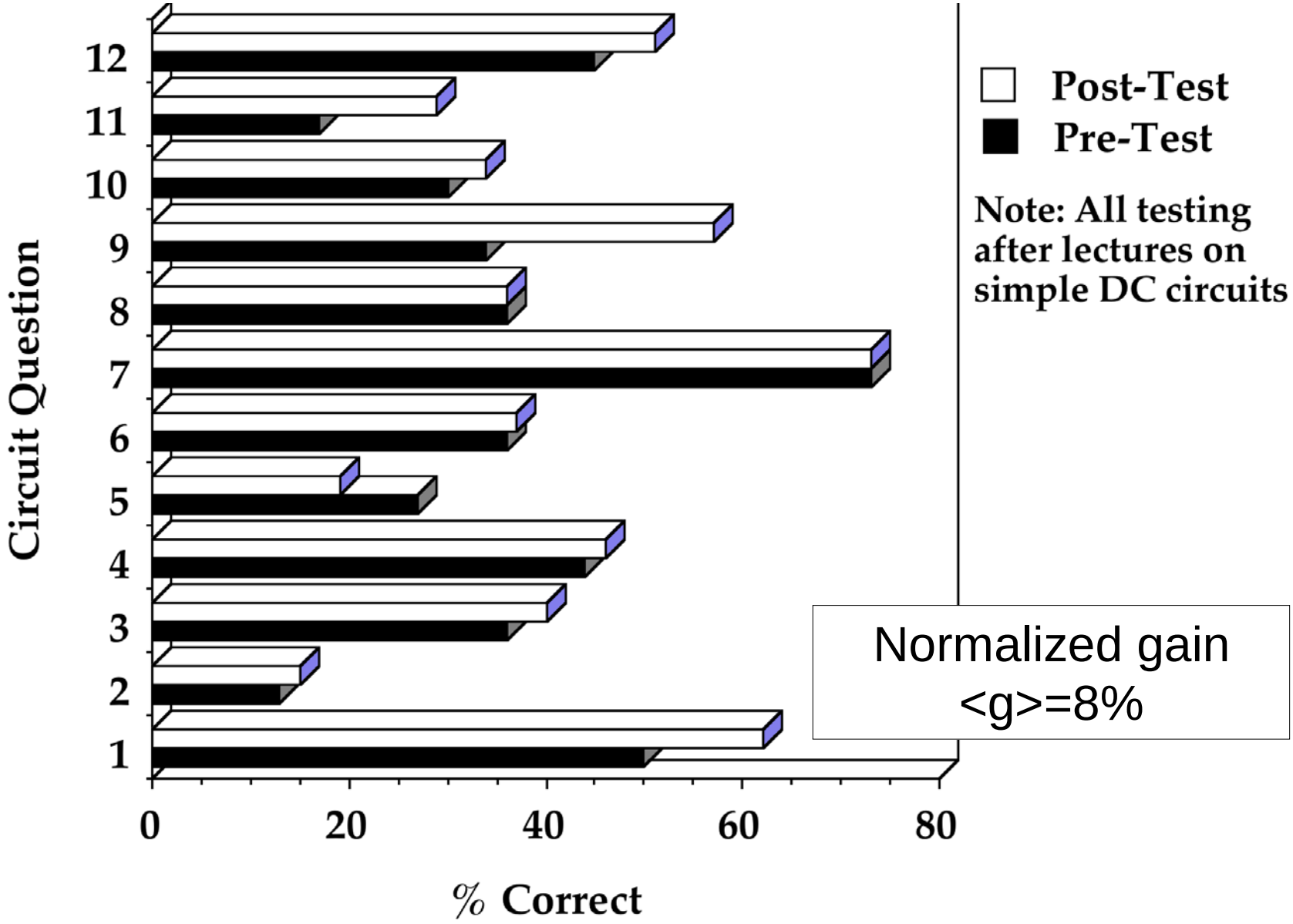
3. Compare the brightness of the bulb connected between B and C now to its brightness before when there was only one bulb.

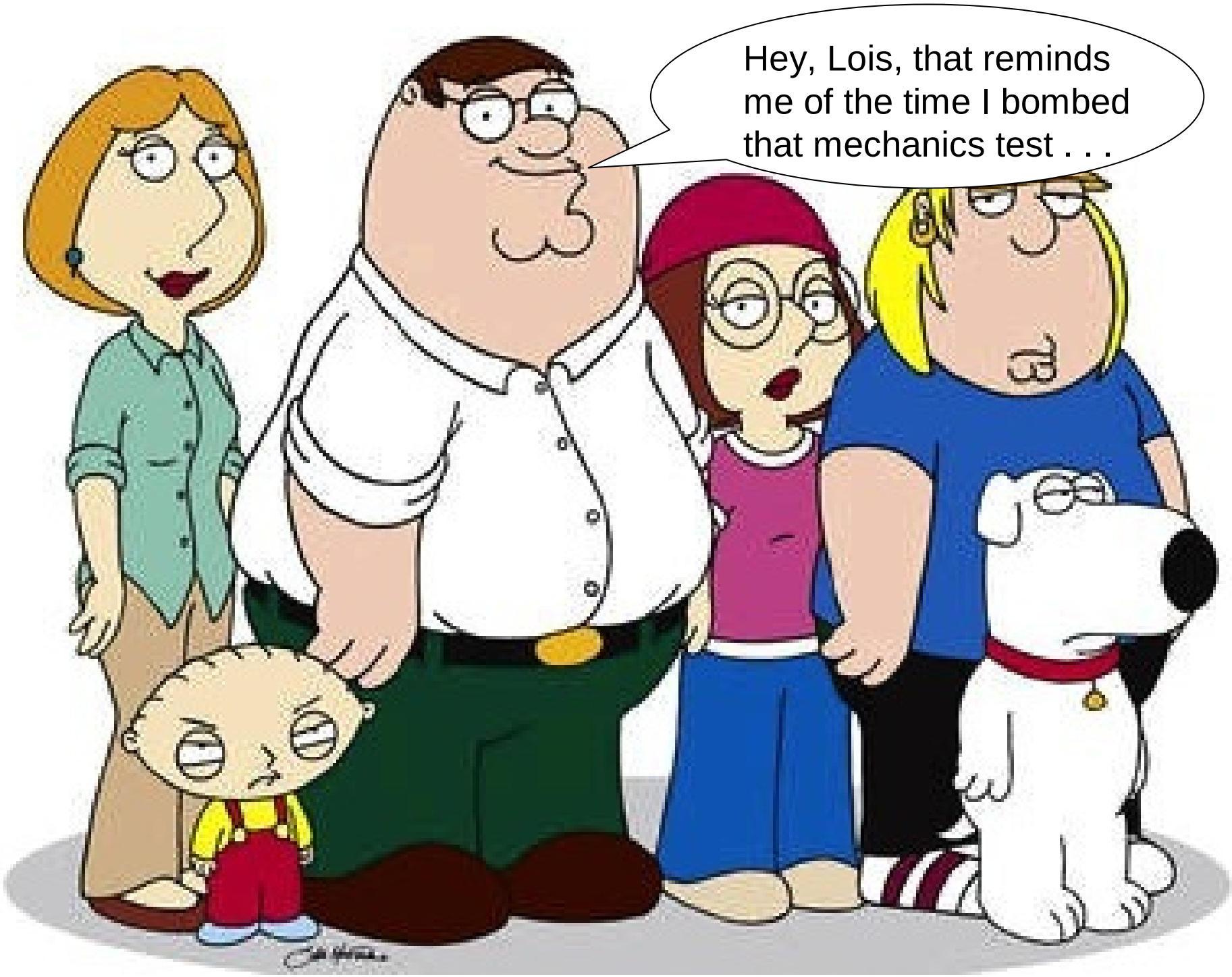
A. The bulb is brighter than it was before.

B. The bulb is just as bright as before.

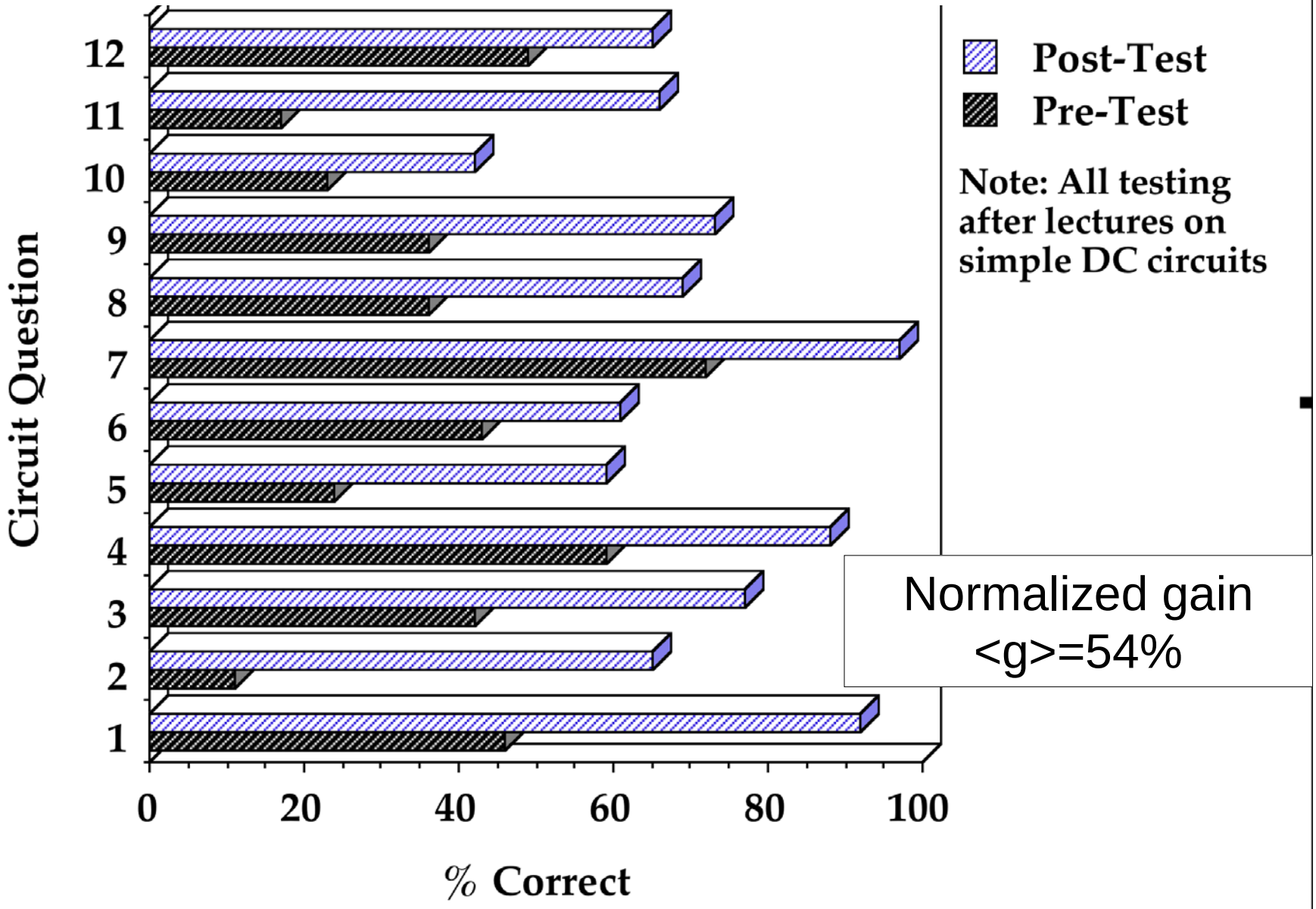
C. The bulb is dimmer than it was before.

Pre and Post-Test Results for Lecture Only




Hey, Lois, that reminds me of the time I bombed that mechanics test . . .

Pre and Post-Test Results for Lab and Lecture



Normalized gain
<g>=54%

LivePhoto Physics

Analysis of physical situations
using Interactive Video Analysis.

I will show you an example of movement of an object, and then you will work with analysis of projectile motion.

LivePhoto Physics

- Short films, usually of 30 frames or fewer, used to analyze physical situations.
- These live images can be analyzed frame-by-frame using *LoggerPro*.
- The positions of objects in the frames can be measured and used to analyze the motion.

LivePhoto Physics

- The data collected can be used to produce graphs, and these can be analyzed and modeled to find physical models.
- Vectors can also be superimposed on the original film.
- Besides mechanics, there are also some nice applications in other areas of physics.

LivePhoto Physics

http://livephoto.rit.edu/

- Here you can find short movies in many areas of physics.
- Also teaching materials: homeworks, projects.
- All of these films can be analyzed using *LoggerPro*.

The
End