AAPT4 Room 270F moderator: Zenobia Lojewska

8:00-8:20

A Physics-First, Math-Later Introduction to Relativity

Rob Salgado; Mount Holyoke College

We present an introduction to special relativity for a nontechnical audience using a new animated visualization of the proper-time elapsed along an observer's worldline. By supplementing inertial worldlines with light-clocks, we use the textbook storyline of the Michelson-Morley experiment to construct the spacetime paths of light-rays associated with these light-clocks. These paths mark off intervals of proper-time in units of "ticks", where each tick is intuitively visualized as the intersection of the future light-cone of one tick-event with the past light-cone of the next tick-event. With the use of radar methods, the measurements of spacetime intervals are then reduced to the "counting of ticks". The resulting space-time diagrams are pedagogically attractive because they emphasize the relativistic view that "proper-time is what is measured by an observer's clock." Although the details of the visualization require some analytic geometry, physical ideas are used to qualitatively motivate the construction. We use the visualization to demonstrate the Clock Effect and the Doppler Effect.

8:25-8:45

The Electromagnetic Field as Surfaces in Space-time

Edward S. Lowry

Central concepts of Maxwell's theory of electromagnetism can be expressed visually with little need for explicit mathematics. The full electromagnetic field of a classical charged particle can be represented by a family of surfaces radiating outward from its world line in space-time. The slope and density of the surfaces
at each point can provide a measure of all six electromagnetic field components. Few images in physics do more to express the essence of a fundamental theory.

This view helps introduce special relativity. It shows how relativistic simultaneity has direct physical significance. It shows how the same force can be seen as purely electric or purely magnetic depending on the frame of reference. It helps show that the traditional view that "changing electric fields produce changing magnetic fields, which produce changing electric fields..." is an over-complication. The main image resulted from translating Maxwell's theory into a computer style language. That approach may help clarify many aspects of physics.

8:50-9:10

SURPISES AND MISCONCEPTIONS

Larry McGrail, Eugene Saletan, Christos Zahopoulos
RESEED program. Northeastern University

For several years we have been working with middle and high-school teachers and with retired scientists and engineers in the RESEED program, trying to sharpen their understanding of Newtonian physics. In both groups many of the participants enter the workshops and training sessions with fundamental misconceptions which need to be overcome before true understanding can be reached. An effective way to overcome these is by demonstrating phenomena that seem at first surprising, for those stay in one’s memory. We present three misconceptions, two with demonstrations that are often found surprising, and one surprising demonstration not associated with a misconception.

1. Misconception. Newton’s third law, or action and reaction.

(a) If a small car (with a powerful engine) pushes a large truck, does it push the truck with more force or less than the truck pushes back? Consider three situations: (i) they are accelerating, (ii) they are moving at a uniform speed, (iii) they are slowing down.

(b) (Particularly relevant for engineers.) Is the force the walls apply to the dome of a cathedral the reaction to the weight of the dome?

2. Misconception and surprise. An under-water accelerometer. In a container completely filled with water a submerged cork is tethered by a string to the bottom of the container. This device is used as an accelerometer. (It is preferable to a simple hanging weight because oscillations are damped by the water.) Describe what happens under acceleration.

3. Misconception and surprise. Lay a spring balance horizontally on a table and tie strings to the bottom hook and to the supporting ring at the top. Drape the strings over pulleys at both sides of the table and hang a 200 g weight on each, to pull the hook in one direction and the support in the other. What will the spring balance read?

4. Surprise not based on misconception. On one wooden stick, hang three weight-and-spring combinations. Hold the stick at its ends and without any apparent motion of the hands make any one of the weights oscillate up and down while the other two stand still.

9:10-9:30

AN INTRODUCTION TO DIMENSIONLESS PARAMETERS IN THE STUDY OF VISCOUS FLUID FLOWS

DAVID GUERRA, KEVIN CORLEY, PAOLO GIACOMETTI, ERIC HOLLAND, MICHAEL HUMPHREYS, MICHAEL NICOTERA, Saint Anselm College, DEPARTMENT OF PHYSICS TEAM

In an effort to help students better understand the role of viscosity and dimensionless parameters, like the Reynolds number, in Fluid Dynamics; we have developed an introductory physics laboratory exercise that examines these concepts in the study a simple fluid flow. The proposed experiment is based on the analysis of the drain-time of water flowing out of an inverted plastic bottle with different sized holes drilled through the center of the caps.[1] The basic premise of the viscosity lab is to test the flow of more-viscous, common, fluids, such as corn oil, pancake syrup, and maple syrup, through the same inverted-bottle system. A simple dimensionless parameter, which predicts the approximate exit hole size at which a Bernoulli's Law/Continuity Equation derivation of the drain time will fail, can be derived for and tested with the experimental arrangement.

[1]"A Bernoulli's Law Lab in a Bottle," Guerra, D., Plainstaid, A., and Smith, M, The Physics Teacher, Vol, 43, No. 7, pp. 456-459, October 2005.