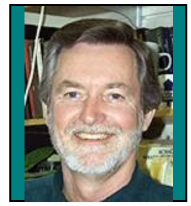
NEWSLETTER

ONTARIO ASSOCIATION OF PHYSICS TEACHERS (An Affiliate of the A.A.P.T., and a charitable organization) February 2010

The Demonstration Corner



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How to Make a Lighted Throwing Stick

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Illustrating the concepts of centre of mass and centre-of-mass motion to an introductory physics class can be a challenge to a physics instructor. The topic can be very mathematically complex and is not necessarily intuitively obvious. A device that demonstrates how the centre of mass of an object moves as compared to the motion of a point on the object away from the centre of mass would provide an excellent qualitative illustration of this. At Dalhousie University we have constructed just such a device, our lighted throwing sticks (Fig.1).

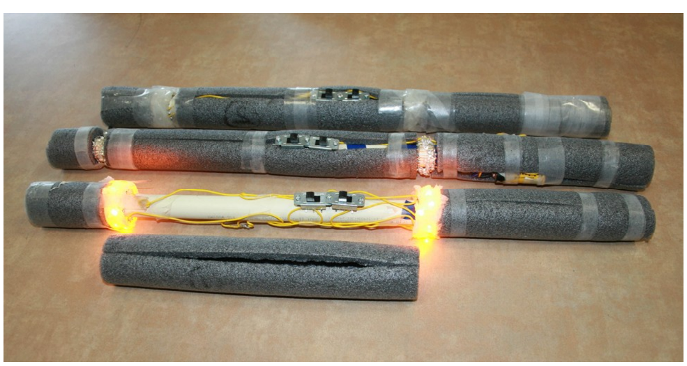

Fig. 1 Three throwing sticks at various stages of assembly.

These throwing sticks are long rods with lighted bands located at one end and at the centre of mass of the rods. By throwing such a rod with the centre of mass lights on, the students see a smooth trajectory of the centre of mass motion, while the end lights demonstrate the complicated motion of points away from the centre of mass (Fig. 2). Jeff Dahn demonstrated our lighted throwing sticks at the 2009 CAP Congress in Moncton, NB.

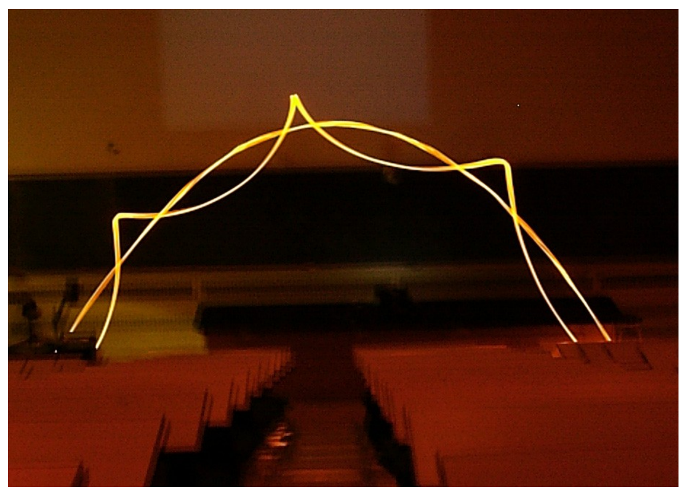

Fig. 2 Stick thrown with both lights on.

At Dalhousie we made throwing sticks from white water pipe (3/4" outside diameter). The lights are made from about 10 to 30 LEDs, oldered around the circumference of two rings as in Fig. 3. The pipe is padded with 3/4" id foam pipe insulation. The LEDs are protected by potting

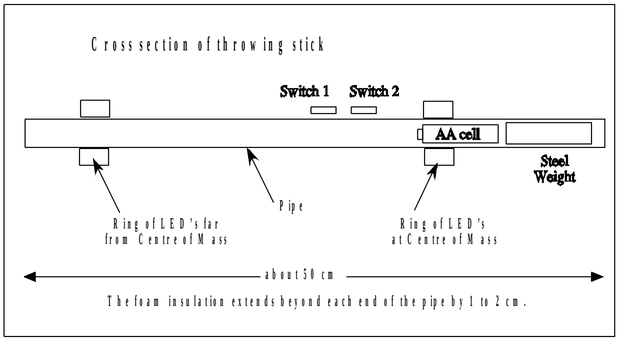

Fig. 3 LED details.

them in clear caulking. A steel mass near one end ensures that the centre of mass is not at the centre of the pipe. One light is at the centre of mass; the other is far from the centre of mass. Each light has an on/off switch. Figure 4 shows the layout of the stick.

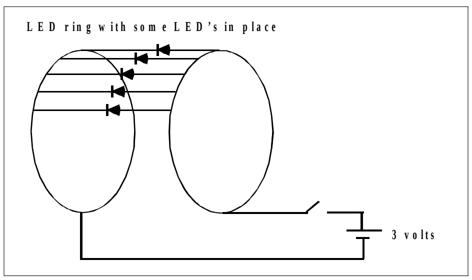

Fig. 4 Details of throwing stick.

Landings are very harmful to the throwing stick. We felt we were doing well if a stick survived 10 throws without failing. We usually operate in lectures with two spares.

Things that helped sticks survive are:

1. We used flexible, braided wire.
2. We used AA cells with solder tabs.
3. We twisted, soldered and taped all electrical joints.
4. We wrapped the pipe insulation with transparent first aid tape.
5. A rubber stopper in each end of the pipe helped but never stayed in place very long.

How to use:

* Throw the stick with only the off-centre light switched on and you see a complex tumbling path.
* Switch on only the light at the centre of gravity. Throw the stick with a tumbling motion and the light will follow a simple parabolic path, demonstrating that the centre of mass is a special place.
* Throw the stick with both lights on and you see both motions as shown in Figure 2.

Supplies: We bought LEDs (in packages of 100) and slide switches from Jameco Electronics, Belmont, California. Everything else came from local hardware stores or pharmacies.

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Submissions describing demonstrations will be gladly received by the column editor.

MOdern PhYSiCS

LEDS and Plancks Constant

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Quantum physics is firmly part of the new 12U curriculum. It also is one of the most difficult topics to teach because it leads to such counter-intuitive ideas and there are almost no experiments or demos that you can do in the classroom. Fortunately, there is one really simple and cheap experiment. This involves measuring Planck's constant with LED's. Different versions of this experiment have been around since 1974[1]. Details about this experiment and

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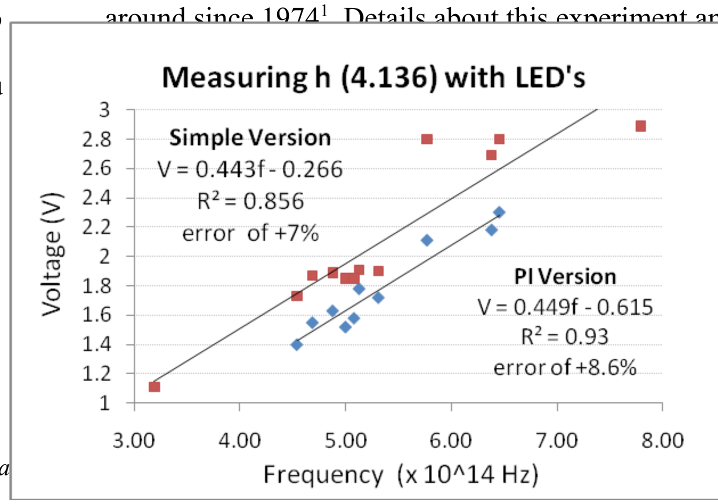


Figure 1: Comparing results of the two versions.

1 LED.

Source charges $5 per LED but they are only $0.25 each from http://alan-parekh.vstore.ca/ . You also need a variable power supply. If you don't have a set of these - and I don't - you can use batteries and potentiometers. What if you don't have the potentiometers? Never fear! Recently I learnt of an even simpler version of this lab through the Alberta Physics Teachers Association. It doesn't need a variable power supply - just a couple of batteries to provide an constant 3V. The LED is attached to the batteries in series with a resistor of 10's to 100's of ohms. The voltage drop across the LED is measured. This is repeated with several different LED's but the same voltage and resistor. A graph of the voltage drop vs. the frequency of the light yields a straight line with a slope of h in units of eV.s. Figure 1 shows results for this simple version and for PI's version.

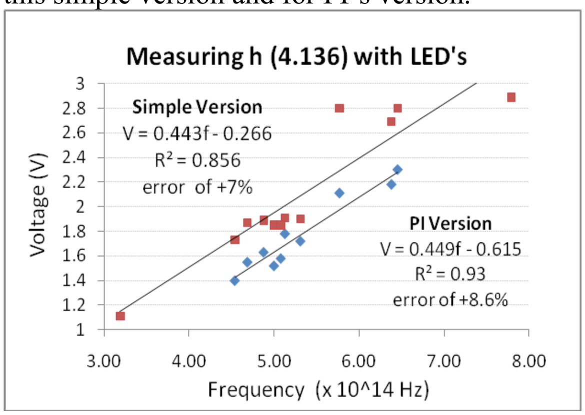
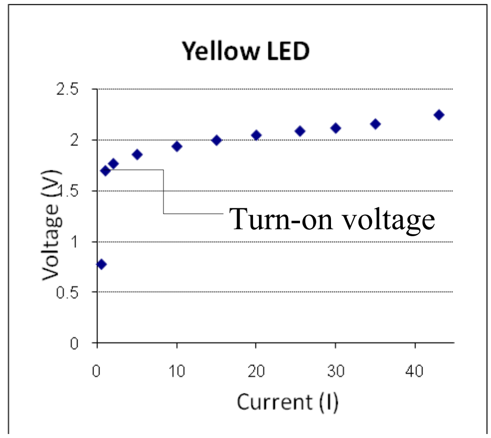


Figure 1: comparing results of the two versions



Why do the slopes give Planck's constant? In an LED, the energy of an electron, eV, is changed into the energy of a photon, hf. An LED is like the photoelectric effect run backwards. There are resistive energy losses and so the graph of V vs. f has an intercept. This intercept is equivalent to the work function. Similarly, just as the photoelectric effect has a threshold frequency, the LED has a turn-on voltage. Figure 2 shows the response of a typical LED to various voltages. When there is not enough energy, then there is almost no current and there is no light emitted. However, when there is enough energy, there is lots of current. Increasing the voltage further makes the light get brighter but it doesn't change its colour. More photons are emitted but they do not have more energy. PI's version of

Figure 2: Response of a typical LED

the experiment has the students adjust the voltage to find the minimum voltage that will cause the LED to emit a photon. This is like adjusting the voltage in the photoelectric effect to find the maximum kinetic energy of the photoelectrons.

Why does the simple experiment still work, when the batteries are providing up to three times the turn-on voltage required? First of all, most of the extra energy is soaked up by the resistor in the circuit – that's what it is there for. The voltage drop across the LED also increases somewhat, but if you look at figure 1, you'll see that each LED is uses roughly the same amount more – around 0.3 V. Because this increase is constant, it increases the intercept but doesn't change the slope. It takes more time, care and equipment to perform PI's version of the experiment but it has many advantages that make it worth the added effort. It results in more reliable data. It allows the students to observe the effect of a changing voltage on the LED, which is so

different from an incandescent bulb. It also provides more similarities to the photoelectric effect – a key part of the curriculum – and it is easier to explain. However, if you are strapped for time or equipment the simpler version is an excellent alternative. This version also allows you to incorporate ir and uv LED's more easily. I recommend that you use them because the added data range from these LED's will help ensure that your results are still pretty good.
There are a number of workshops being presented by the Perimeter Institute coming up in February and March around southern Ontario. At these workshops teachers will receive free materials and training for this LED lab PI's new resource package - The Challenge of Quantum Reality. If you are interested in attending one of these workshops and want more details, please contact me at roberta@tevlin.ca .

Reader's Corner

Third Edition

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Physics of the Impossible. Kaku, M., New York:
Reviewed by Keith Poore and Edna Sacay
(Physics Students at Ryerson University)

As you read a science fiction book or watch a sci-fi movie and wonder if it is possible to travel in time, see the future with precognition or hide yourself in an invisibility cloak, reading the *Physics of the Impossible* by Michio Kaku will help you answer some of your most burning questions. In his reader-friendly book Kaku applies the laws of physics to science fiction in order to understand why some of the science fiction inventions will never become a reality, while others might materialize once new technologies become available. The author reveals the milestones that need to be overcome by the current technology and civilization in order to make some of the current science fiction "impossibilities" happen. Kaku is a theoretical physicist specializing in String Field Theory. He received his Ph. D. in theoretical physics from the University of California, Berkeley. He has been teaching for more than 25 years at City College of New York, has been a host of numerous TV and radio shows and had given a large number of public talks

The *Physics of the Impossible* is aimed at the general public and will be of greater interest to high school students and their science teachers. Kaku explains the fundamental laws of physics before explaining the barriers that must be overcome before the "impossible" become possible. The book naturally has many science fiction references such as Star Trek, Harry Potter and Superman, for the readers to relate to when explanations appear to be complex. The absence of mathematics allows for the general audience to grasp ideas that are portrayed without getting caught up in the numbers.

Kaku intrigues the reader by covering topics that appear commonly in science fiction such as time travel and artificial intelligence. The book conveys great mental imagery so it can be understood to a better extent. He also leaves 11 pages of notes allowing the reader to understand material better. An index is also included to help find specific topics like *metamaterial* which will help to show the relation between different topics. The reader will soon realise that the book opens doors to a more in depth exploration of the topics thanks to the references in the bibliography.

The book is well organized because of how Kaku presents the information within three different classifications of impossibilites. Class 1 impossibilities are technologies that can be achieved within a decade to a century. Class 2 impossibilities are technological advances which could be possible anytime from a millennium to multi-millennia from now. Class 3 impossibilities are the ideas and concepts of technology that will never be attained unless there are drastic shifts in our understanding of the fundamental laws of physics. Kaku has also thoughtfully organised concepts in such a way that builds from previous knowledge explained within preceding impossibilities.

In our view the lack of diagrams and mathematics weaken the book's overall portrayal of concepts. For example, when explaining different types of spacecrafts that could theoretically be built, diagrams would have been sufficiently helpful in understanding the theory behind each spacecraft. Simple mathematics would include showing the formulae describing fundamental physical concepts and explaining what the variables and constants were.

For example, referring to Snell's Law would have been ideal when introducing the idea of invisibility.

This book could help teachers explain physics to students, even if the students have not taken a physics course before. Topics that are usually hard to understand such as, special relativity and quantum mechanics, are explained using imagery that helps the reader understand the concept. This is made apparent in the Perpetual Motion Machine impossibility when Kaku compares the three Laws of Thermodynamics to a game.

Overall, Michio Kaku does an excellent job in conveying the physical impossibilities of science fiction of today illuminating what could be possible in the future. The *Physics of the Impossible* is recommended to anyone who is remotely interested in physics. Although some concepts are hard to grasp, this book exposes the general public to what is currently physically impossible.