Purdue University

NOMINATION FORM FOR

HELPING STUDENTS LEARN AWARD

Michael R. Melloch

Name of Nominee

Professor of Electrical & Computer Engineering

Title

School of Electrical & Computer Engineering — *Department*

765-494-3528 melloch@purdue.edu — *Phone Number and email address*

West Lafayette — *Campus*

Electrical Engineering (BHEE) — *Building*

Title of Innovation

Helping Students Develop Mental Models for Electromagnetics

Name of Nominator

(if other than self)

Address

Phone

Nominations must be sent electronically to cie@purdue.edu. Nominations must be received no later than 5 pm, Monday, January 30, 2023.

Since joining the faculty in 1984, I had only taught ECE 311 Electromagnetics two times before becoming the ECE Associate Head for Education in the Fall of 2008. (I will refer to this course as ECE 30411, which it was renumbered to the Fall 2019 semester.) One of my duties as Associate Head was making teaching assignments. I had instructors assigned for all courses except for ECE 30411 that Fall 2008 semester. To complete teaching assignments, I assigned myself to teach ECE 30411.

As Associate Head my responsibility was Education. I wanted to have informal discussions with our undergraduates to find out their perceptions of being a student in ECE. I started to meet for lunch with groups of 4-5 students from my ECE 30411 class. One of the first things I learned was how much the students in ECE dreaded taking ECE 30411! Most students want to find and memorize algorithms to solve problems they will encounter on exams rather than develop mental models of the concepts. ECE 30411 uses vector calculus to represent and manipulate electric and magnetic fields. Because students look for algorithms to solve problems, along with the vector calculus nature of 30411, the course becomes a mathematical abstraction. The students do not develop mental models with which to envision electric and magnetic fields. They do not learn concepts, just procedures. This is a difficult and uninteresting approach.

Taking a course in electromagnetics should be an interesting, and enjoyable, experience for ECE students. Even though my field is microelectronics and not electromagnetics, I decided to continue to teach ECE 30411 to find ways to make the course the best experience my students would have in their undergraduate careers. (From comments in my evaluations I have been successful.)

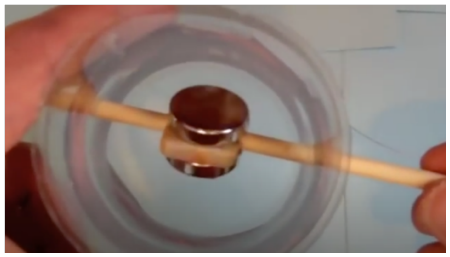
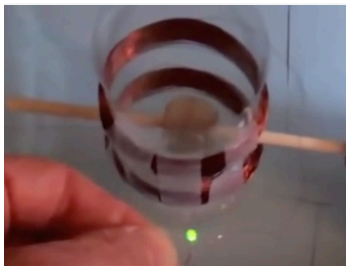
For students to develop the mental models, I decided I had to help them visualize what was happening. I did this by developing demonstrations. For the demonstrations to be memorable they had to be simple and made from ordinary items.

Over the last 10 years, I have developed about 50 **novel** demonstrations that **facilitate** the learning of the course concepts. I can do many of these in class because they are simple and don't take up too much precious class time. I then decided to video the construction and operation of the demos to provide to the students on Blackboard, now on Brightspace. This way the students could watch a demonstration they saw in class, and I could include construction details with which the students could build the demos if they chose. (Many students have told me they have built some of

these demonstrations.) After the semester, I was being contacted by students wanting access to the videos, which were on the Brightspace site and no longer available to them. To provide access, I started a YouTube channel. This channel has had **broad impact** with over 23,000 subscribers and 4.4 million views. I answer several questions every day from viewers all around the world.

Let me describe three of these demonstrations with screenshots from the Youtube videos that illustrate the novel nature of these demonstrations.

AC Generator

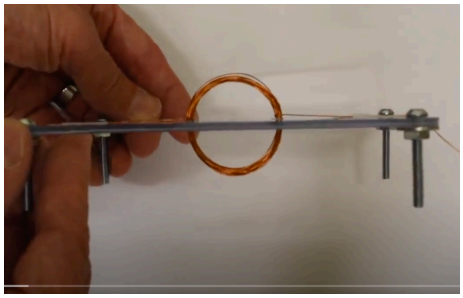
The figure on the left shows a plastic water bottle that has had the ends cut off and on which a wire has been wound. In the center figure we see the water bottle rotated 90 degrees, so we are looking down the center of the bottle. A small diameter dowel rod has been inserted on which are attached two magnets. In the figure on the right a green light emitting diode has been attached to the two ends of the wire. Rotating the dowel rod rotates the magnets producing a changing magnetic field inside the coil, which produces a current in the coil and turns on the green light emitting diode. This gives the students a mental image of "Faraday's Law," which is no longer just a mathematical abstraction. This is the principle used at utility power plants to produce electricity.

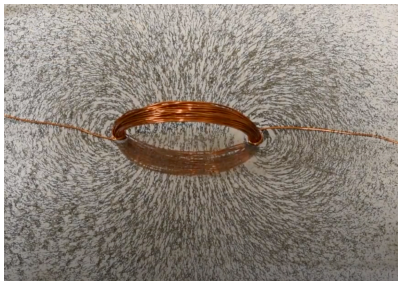
Loudspeaker


In the figure on the left we see a wire that has been formed into a coil taped to the bottom of a cup. The wire is also attached to the output of a CD player. The signal from the CD player produces a current in the coil. This current in the coil produces a magnetic field. The strength of this magnetic

field varies with the strength of the current, which varies with the output of the CD player. The figure on the right shows a permanent magnet held near the coil on the cup. The strength of the attraction between the permanent magnet and the coil varies with the signal from the CD player vibrating the bottom of the cup and producing remarkably excellent music.

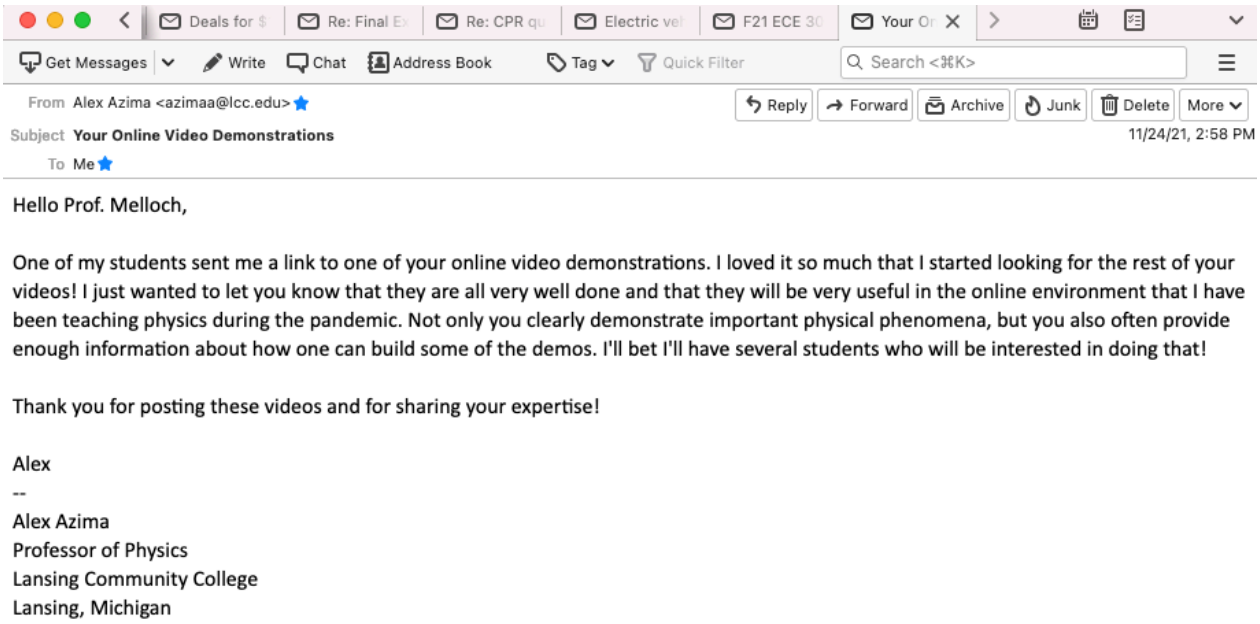
Magnetic Field of a Coil





In the figure on the left we see a coil has been wound through two holes in a piece of plastic so that the plastic goes down the center of the coil. In the middle figure iron filings have been sprinkled on the plastic. Passing a current through the coil generates a magnetic field that rotates the iron filings as seen in the figure on the right. The students "see" the magnetic field.

With over 23,000 subscribers I receive many notes and comments. Below is an email I received concerning my YouTube channel from a community college professor:



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Get Messages | Write | Chat | Address Book | Tag | Quick Filter | Search <⌘K>

From Alex Azima <azimaa@lcc.edu>

Subject **Your Online Video Demonstrations**

To Me

Reply | Forward | Archive | Junk | Delete | More

11/24/21, 2:58 PM

Hello Prof. Melloch,

One of my students sent me a link to one of your online video demonstrations. I loved it so much that I started looking for the rest of your videos! I just wanted to let you know that they are all very well done and that they will be very useful in the online environment that I have been teaching physics during the pandemic. Not only you clearly demonstrate important physical phenomena, but you also often provide enough information about how one can build some of the demos. I'll bet I'll have several students who will be interested in doing that!

Thank you for posting these videos and for sharing your expertise!

Alex

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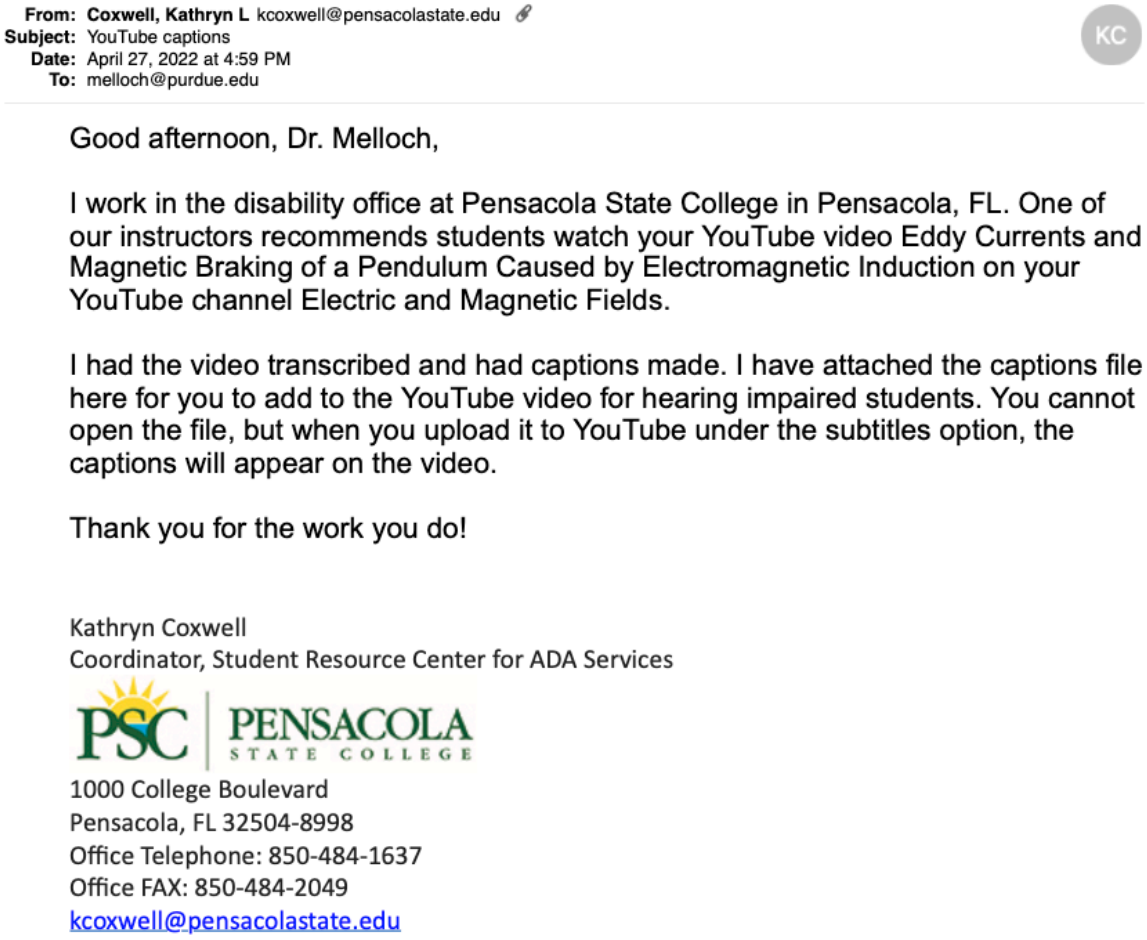
Alex Azima
Professor of Physics
Lansing Community College
Lansing, Michigan

Below is another note I received from a disability officer at Pensacola State College where they are captioning my YouTube videos for their students.



From: **Coxwell, Kathryn L** kcoxwell@pensacolastate.edu
Subject: YouTube captions
Date: April 27, 2022 at 4:59 PM
To: melloch@purdue.edu

KC

Good afternoon, Dr. Melloch,

I work in the disability office at Pensacola State College in Pensacola, FL. One of our instructors recommends students watch your YouTube video Eddy Currents and Magnetic Braking of a Pendulum Caused by Electromagnetic Induction on your YouTube channel Electric and Magnetic Fields.

I had the video transcribed and had captions made. I have attached the captions file here for you to add to the YouTube video for hearing impaired students. You cannot open the file, but when you upload it to YouTube under the subtitles option, the captions will appear on the video.

Thank you for the work you do!

Kathryn Coxwell
Coordinator, Student Resource Center for ADA Services
PSC | PENSACOLA STATE COLLEGE
1000 College Boulevard
Pensacola, FL 32504-8998
Office Telephone: 850-484-1637
Office FAX: 850-484-2049
kcoxwell@pensacolastate.edu

I often receive notices from YouTube of copyright infringement of my videos. This is where someone has embedded part, or all, of one of my videos into their videos. If someone is obviously just doing it to market my video as their own, I submit a removal request. When someone has used my video in a video they have created for their own class, which has happened often, I will not submit a remove request because my goal is for a **broad learning impact** and to call attention to electric engineering at Purdue.

My students respond very favorably to the demonstrations and the videos as can be seen in the following sampling of student comments.

On 5/10/21 1:12 AM, Christopher Donald Magdall wrote:

Hello Professor Melloch,

On another note, thank you for a great year. Out of my 3 years at Purdue, I can truly say you are one of the best professors I have ever had. I can tell you put a lot of work into your teaching, and truly care that you are teaching the material well. Your demonstration videos made the class extremely enjoyable and relevant. I was always in amazement watching those. Keep up the good work, it's because of professors like you, that learning is fun!

Sincerely,
Chris Magdall

I think the demonstrations are very beneficial to giving the students a visual connection to what often is hard to visualize. (Fall 2020)

The videos that demonstrate devices that can be made using the principles introduced in this class help keep my attention. (Fall 2020)

The demonstrations are extremely interesting to watch and help reinforce concepts in this class. (Spring 2021)

I really liked the demos in the class. I felt I was able to actually understand many of the concepts which I previously had failed to learn properly in my other classes (Fall 2021)

This class was the most fun I had all semester. The demonstrations were really engaging and the extra time took to really make the math less abstract was really helpful. (Spring 2022)

the in-class experiment demonstrations are really interesting and helpful in learning the key concepts. (Fall 2022).

The demo's in class really help with my undsertanding [sic]. I've covered a lot of these topics briefly a few different times during my education so far and this is the first time i've [sic] understood any of it. (Fall 2022)

To summarize:

1. The demonstrations facilitate learning by providing students with a visual image of the course concepts.
2. The demonstrations are novel in that very simple items are used to construct them.
3. The broad impacts are that not only are they benefiting the students at Purdue taking ECE 30411, students and teachers around the word are utilizing the videos of the demonstrations.
4. The student comments show they feel these demonstrations allow them to learn the concepts, the material is not just abstract equations anymore.