A Contemporary View of Introductory Physics: A Distance Learning Course for In-Service High School Teachers

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Matter & Interactions ("M&I")

A contemporary approach to the calculus-based introductory university physics course, featuring

Emphasis on the atomic nature of matter.

Emphasis on the reductionist nature of physics, that a wide range of phenomena can be understood using a small number of fundamental principles plus simple atomic models of matter.

A serious introduction to computational physics, which is now a full partner to theory and experiment.

Textbook

Matter & Interactions, Ruth Chabay and Bruce Sherwood
Wiley 2007

Vol. 1: Modern Mechanics

Vol. 2: Electric & Magnetic Interactions

Where M&I is used

Currently used in the course for engineering and science students at NCSU, Purdue, and Georgia Tech, and at some smaller universities, liberal arts colleges, and community colleges.

In Fall 2006 NSF awarded a "Phase 3" grant to a collaboration of NCSU, Purdue, and Georgia Tech to further develop the curriculum and disseminate it to other universities.

M&I for in-service high school physics teachers

A distance learning version of M&I is being offered to in-service high school physics teachers. The intent is not to train teachers to teach this college curriculum in high school but to broaden and deepen their culture in physics.

The teachers have the opportunity to see physics, including classical physics, in the larger context of the contemporary physicist's view of the discipline, with emphasis on the insights of 20th-century physics.

In addition to experiencing the new approach, teachers post reflections in a course forum on how this contemporary viewpoint may affect their own teaching.

Components of the course

Textbook (Matter & Interactions)

Interactive video lectures

WebAssign computer homework system

Course web site

Experiments (may involve video of data acquisition)

For E&M, a desktop experiment kit

Computational physics (in VPython, see vpython.org)

Course forum, including reflections

Email

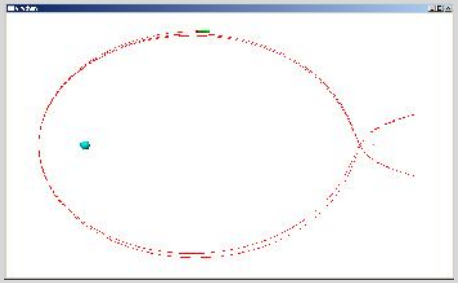
Scan/Fax/pdf submissions of reports/tests/etc.

Weekly teleconference (Elluminate)

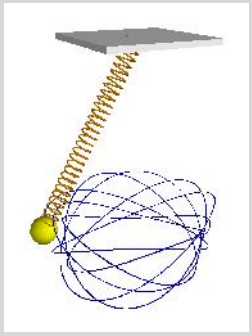
Computational physics with VPython

Teachers write computer programs using VPython to model physical systems, and to see the Newtonian Synthesis in action: starting from initial conditions, repetitive updates of momentum and position can predict the future.

Here is a teacher's program for a restricted three-body motion, a spacecraft orbiting a fixed Earth and Moon.



Here a teacher has written a program to model the motion of a spring-mass system in 3D.



Teacher reflections

Here are example of teacher reflections during the course:

On the general approach; fundamental principles plus atomic nature of matter: "Well--I am rather astonished at the number of topics related in chapter 4, where the real power of this innovative and quite unique approach really begins to bear fruit (IMHO). Using the momentum principle along with macro-micro ideas to bring statics, dynamics, circular motion, the model of a solid, Young's modulus, the speed of sound in a solid, buoyancy, pressure... together conceptually is really cool. (e.g. Archimedes principle seemed so much easier to explain when inserted into the curriculum this way.) This course makes me wish I could go back again and take this for the first time -- as a physics virgin -- to carry out this dangerous analogy just a bit further -- I almost feel violated by the presentation of introductory physics I was subjected to (BS Physics in '86 -- this is so different than the presentation I was given back then-- the times they are a changin'-- in exciting ways)

On the value of an atomic approach to matter: "I am seeing how the line between chemistry and physics is a fine one and not a solid one. In the past, I believed that most things that had to deal with atoms or at the atomic level was chemistry and I didn't need to teach it because "they would get it in chem class." I like the thought that I can work with the chemistry teachers and hopefully help the students understand both courses better."

On writing a VPython program to do a numerical integration of a spacecraft going to the Moon: "I am late turning in my lab but I just wanted to say COOL. I was a little frustrated with technical difficulties and time constraints in my personal life, but this was entirely awesome. I don't know if you could call what I have experienced doing this lab an aha experience or not. I have definitely developed a better conceptual understanding of the nature of the net gravitational force on the craft and its change in momentum, and effect on its orbit. I cannot wait to show this to my classes this semester. WOW!!!"

On a microscopic view of circuits: "I think what we are studying now are some really "neat" concepts. Two and a half years ago during a discussion on circuits, a colleague handed me an earlier version of Chabay and Sherwood's E&M text and said I should read chapter 18. For me it was an epiphany. I knew that the current in a series circuit was the same everywhere but had no mechanism to explain why. With my students the only explanation I could offer was "That's how it is." or "Somehow it knows." The two points that made it all clear to me were what we are now studying. 1. The harder it is for the charge to get through a conductor the stronger the electric field needs to be to keep the charge flow constant, and 2. Uneven surface charge distributions cause the electric fields necessary for the circuits to achieve steady state. For me, those concepts are the most eye opening I have picked up in the last two and one half years. Learning this is the reason I decided to take this course. I figured if I could learn something that "neat" from their book, there was much more to be learned. I was correct.

One thing I don't understand is why these concepts are not more widely publicized. They explain so much, but I have not seen them in any other text."

Interactive video lectures

Lectures involving interactive clicker questions were videotaped

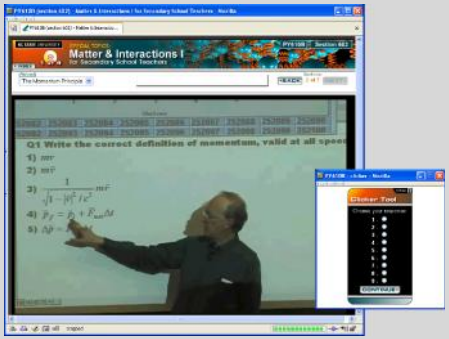
Video edited and compressed; 10 lectures per CD

Video segments end with a clicker question on screen

Simulated clicker appears for distance learner to respond

Next segment begins with display of the histogram of the original student responses with discussion

Effect is to provide much of the interactivity of the original lectures



For more information

The M&I web site offers articles about the curriculum, free downloadable lecture demo software, design of the experiment kit for E&M, etc. See

http://www4.ncsu.edu/~rwchabay/mi

VPython is a 3D programming environment based on the Python programming language. It is free, open source, multiplatform (Windows, Linux, Macintosh). It generates navigable 3D animations as a side effect of physics computations. See

http://vpython.org