MECHANICS REFLECTIONS
on **Matter & Interactions I** course taught by Bruce Sherwood at NCSU in spring semester 2006

Here are some revealing comments posted to the course forum by high school physics teachers in the Spring 2006 distance learning version of **Matter & Interactions I** (mechanics). These are mature learners who are also articulate, and they are in a position to compare the **Matter & Interactions** instruction with the traditional intro course they had in college. The notes are in chronological order.

Teacher #1 (on starting with momentum): "I do want to say that I was surprised that we started the course out in momentum. I don't believe that I have taken a course before that treated momentum as much as this course appears to. I have rarely taught it, as momentum is one of the topics saved for the end of the semester and there usually is no time at the end of the semester. I feel now that I have cheated my students by not covering momentum this semester. After all, it is a word they like to use often, despite the fact that few of them truly understand what it means."

Teacher #2 (on writing a Vpython program to do a numerical integration of a spacecraft going to the Moon): "I am late turning 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 ahha 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!!!"

#3 (on the atomic nature of solids): "For years I've been teaching Young's Modulus with never really appreciating (or for that matter, even knowing)the significance. No previously used textbook has ever spelled out the atomic relationships between stress and strain and Young's Modulus role in relating these two physical attributes. It's making these kinds of connections and associations that keeps me motivated in this course. Thanks Bruce."

#4 (on the atomic nature of solids): "My Physics teacher was excellent and taught the course in a manner that made the material accessible to all of us. It followed pretty normal organization - Newton's 3 laws, energy and work, yadda yadda yadda - but he got us involved in all of it.

I clearly remember Young's Modulus at one point. I supposed it was when we studied springs and such. I remember thinking and even saying to a friend that it seemed totally out-of-left field. It seemed like an engineering, real-world problem dropped in the middle of a bunch of theory. How did it connect? Why was it there? Why was the book suddenly talking about strain and stress and shearing abd breaking and stuff, when we were just reading about springs?

Now that I've completed the third chapter and the material on Young's Modulus and the way that it can be modeled by springs, it seems natural, but at the time it just seemed like something that the textbook authors threw in for some unknown reason."

#5 (on the general approach; fundamental principles plus atomic nature of matter): "Well--I am rather astonished at the number of topics related in chapter 3, 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, dyanmics, circular motion, the model of a solid, Young's modulus, the speed of sound in a solid, bouyancy, pressure... together conceptually is really cool. (eg. Archimedes principle seemed so much easier to explain when inserted into the curriculum this was) 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)

Can't wait for energy :-)"

#6 (on energy graphs, and starting from fundamental principles): "My understanding of minimum escape speed and bound and unbound systems has been greatly helped by the energy graphs we are using in this course. I recall memorizing the escape speed equation (just as the text and Bruce says NOT to do) with little or no comprehension of what it really meant or how it was derived during my first university physics course. As I recall there was a paragraph or two about how K+U=0, and then a derivation, but I did not understand why that had to be so. Now, that I have been given another representational tool--the energy graph--I finally feel like I'm getting a solid handle on understanding. It wasn't until I truly analyzed the graphs of K+U>0, K+U=0 and K+U<0 that I understood what was happening!"

Teacher #2 (on M&I placing the physics in a modern context; note that she is currently teaching in a community college): "I teach physics and geology at a Community College in Sanford, NC. Recently some of my Calc. Physics Students have been reading up on relativistic motion. One in particular came to me and asked why the Physics Principles we were learning all year did not apply to objects moving near the speed of light or to atomic particles. He was very upset by this assumption. Wow !!
Finally I really saw the advantage MI. I do not assume to have an in debth understanding of everything we have covered but I do understnd one thing.... the physical principles are basically the same in the micro and macro world. I could not help but wish I was teaching Physics 251 and 252 using the MI approach. Of course I was better prepared to answer some of his questions and point him in the right direction.

These questions this particular student asked were not uncommon. I really like the MI approach. I feel it serves as a bridge into more in depth physics topics. I had that 3rd semester physics class (probably modern mechanics) that Bruce said a Physics Professor referred to and boy do I wish I had this approach before that one.

I feel as if this course is retraining the way I think about Physics. Although I do not hold a Physics degree, I am a physics buff and enjoy teaching it. I have found myself presenting new material through the momentum principle in my lower level classes. However, I am stil using the traditional syllabus and we aren't supposed to "mention" momentum for another week or so."

#5 (on the general approach): "I greatly appreciated the clear -- momentum principle => time ; energy principle => distance presentation. These nuggets greatly facilitate my understanding and ability to approach problems and novel applications. I consider my learning style-- having always resonated best with the big ideas that I can sink my teeth into and bank on, it feels natural for me to think along these lines... What are the fundamental truths which provide structure for a self-consistent world-view? When presented with new information, how can I evaluate it in terms of my present schema? Does it fit in with the truths I hold to most dearly or does the info shake the foundations of my understanding? It is in this sense that I most appreciate the approach of M&I thus far. It presents intro physics in the light of current

understanding without some sense of irrelevance or "dumbing-down" of the material. If physics had been presented this way when I originally pursued the discipline (or if I was brilliant enough to grasp it on my own ;-), I may have gotten beyond my BS. Instead, I jumped into industry and found the fundamental issues in quality improvement. When I entered education as a teacher, I was asked to teach mathematics and fundamental ideas... number, variables, algorithms...seemed clear enough that I could find fun and creative ways for students to approach them. It was easy for me to get out of popular (often bland) texts. In physics, I have always been a decent problem solver, but never felt I fully mastered the truths of the subject. I just haven't pursued physics seriously in so long...it is great fun to feel the lights slowly coming on in a deeper sense. As the physics coordinator (glorified TA) for DUML physics, I know that by the time I get through the second course in the sequence, I will have much more to offer students than some help with completing a homework problem or understanding a particular lab or explaining the rationale for points lost on a quiz/exam question. I'll be better able to explain some real physics.

#1 (on the value of an atomic approach to matter): “I do enjoy the new approach that we are taking to physics topics that I thought I understood. I am finding that many topics I thought I understood or things that I just accepted are finally making sense to me. I could never explain to my students what the "normal" force was to my satisfaction. To me, it just makes sense. I usually got the students to go along with me, but I never felt that I was very convincing in my arguement. Now that I have seen how to approach it microscopically, I think that I can do a much better job of explaining what the "normal" force is. I also feel much better being able to discuss energy with my students. When they bring up E=mc^2, I feel that I will actually be able to discuss it with them and why we don't typically see it in most calculations that we make.

I also am seeing how the line between chemistry and physics is a fine one and not a solid one. In the past, I belived that most things that had to deal with atoms or at the atomic level was chemisty 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.”

#7 (on photon emission and absorption): “I just had a very pleasant experience with my son. He is learning disabled and is in his senior year at university. He is taking astronomy as a general elective. He has a test tomorrow on the property of stars. He came to me for a little help. Thanks to our recent discussion on emission/absorption of photons, I was able to give him reasonable guidance on stellar spectral lines and dark absorption lines. I was at least more competent than I would have been last week. This was a very gratifying moment for me.”

#8 (on dealing correctly with work and energy for multiparticle systems): “This is a brief comment about the chapter 7 work so I thought would fit with this topic stream: I loved the direct -- compare + contrast -- approach you have taken with the point-particle vs "real" system application of the energy principle. I had often been frustrated with texts which work out problems by treating rigid objects as points without any justification. It also seems that most traditional texts jump into "rotational" kinematics and angular momentum without ever doing this cool comparison -- showing the different information which can be obtained by applying the energy principle to a "point-particle" vs a "real" system. I think your approach will help many students make more sense of angular momentum concepts-- can't wait to see how it develops.”

#7 (on education for preservice and inservice science teachers): “It has taken me awhile to return to this topic, but I finally found my answer in an article I found on the Raleigh News and Observer website. The article “Tough Task Set for Teacher Training” was written by Jane Stancill and published: February 20, 2006. Raleigh, North Carolina is the home of North Carolina State University. NCSU is one of 16 universities in the University of North Carolina System. The University of North Carolina at Chapel Hill is another well known member of this system. This statewide system is administered by the University of North Carolina General Administration. The current UNC system President Erskine Bowles has ratcheted UNC system President Erskine Bowles has put pressure on the universities in the system to produce swift, superior solutions to North Carolina’s public school teacher shortage. In the article Charles Duke, dean of the Reich College of Education at Appalachian State University (another constituent of the UNC system), was quoted as saying two of the state's greatest needs are math and science teachers. But, he added, not many biology and math majors are getting teaching credentials. Duke said Appalachian will investigate ways to encourage students into math and science education and "make them understand that being a physics teacher is one of the best things they could do with their lives." The following is a direct quote from the article: ‘That could be an uphill battle. In the past four years, Bowles said, the UNC system has turned out only three physics teachers. Some of that is because of the profession's low pay and working conditions, Bowles said. "And some of it is because, you know, we haven't really done our job. We gotta do better. We can do better"'

What this says to me is that a lot of physics teacher in NC are like me. They have the certificate that allows them to teach physics but not the knowledge to teach it adequately. I have tried to increase my knowledge of physics at my local university. Why would I want to take undegraduate classes that I already had in college and that do nothing to advance my pay? At my local university, I took graduate History of Physics and Current Trends In Physics. These were the courses it was deemed I could understand with my limited background. I learned a lot, but little that deepened my understanding of basic physics.

I am grateful to the Physics Department at NCSU and in particular Dr. Haase and Dr. Sherwood for already doing something for the "physics" teachers in this state. Although the two physics courses for secondary high school teachers that I have taken from NCSU last fall and this spring obstensibly review undergraduate topics, they go much deeper than that. These two courses have taught me a lot about not only physics,but also physics pedagogy. In Dr. Haase's class we read papers on physics education research. During this course I have almost felt like a student teacher. Not only do I gain content knowledge as I watch the lectures, but I also get to watch someone teach physics. And I got to do it for a whole semester, not the nine weeks of student teaching required when I was certifying. My husband says that he can tell I have learned more from this course than any other. Which I guess is the most important thing-not whether it carries graduate hours or not. I hope that I will be able to take the second half M and I.”

#2 (at end of course): “I have enjoyed the challenge and new approach M&I has offered. The first ahah experience occured when I realized you could derive all the kinematics equations using the momentum principle. I excited to see that kinematics, vectors and momentum could be presented in a compact manner and yet with a greater depth. Many first year High School and College instructors are all too aware that kinematics can sometimes take too much time to go through, thus leaving momentum and energy as blurbs at the end of the semester. I really like the way the three basic principles can be used to cover the broad spectrum of classical physics.

Systems have always troubled me. Now I feel that I have a much better clarity on choosing systems and analyzing them. This has helped recently in my classes. I have been sucessful at addressing system choice

related questions.

Statistical Mechanics is just awesome. I love it. The M&I approach has really helped clear up a foggy understanding of entropy. I want to take Themo now... the one class I dropped in Undergrad."

#1 (on the value of an atomic point of view, and emphasis on fundamental principles): "Thanks to this class and its unique approach, I feel that I understand many topics more clearly and therefore feel more confident in discussions with them. The atomic approach really helped me. I feel more comfortable explaining certain interactions and energy of atoms. I especially feel more confortable with rotational motion now that I've had the opportunity to work with it. It doesn't seem nearly as scary as I used to think it was.

Overall, I really enjoyed this course and working with everyone as well. Having fewer principles instead of just many, many equations, really did help me understand how things are related. I still can't believe how we made it through an entire course and hardly talked about acceleration!

I really hope to be able to take the E&M course in the fall. It would be great to see you all there!"