10 April 2007

Greetings again,

First, we all need to know that Group 3 now has four members total. They are

Jan Tobochnik, Kalamazoo College	jant@kzoo.edu
Kelly Roos, Bradley University	rooster@bradley.edu
Michael Gray, American University	gray@american.edu
David M. Cook, Lawrence University	david.m.cook@lawrence.edu

Second, I want to thank you all for your responses to me initial email about the activities we will undertake at the WORKshop in early May. I have received responses from all of you and I thought I should assemble them into a single document and make sure everybody has a copy. The rest of this email contains that compilation. Over the next several days, I will try to find time to compact your collective remarks—and any additional comments or thoughts you choose to send me—into a more readable document that may serve as the jumping off point for further emails and certainly for our discussion at the beginning of the WORKshop.

In his response, Michael has asked a number of questions, and I have interpolated my responses to those questions in his email below, enclosing my remarks in <<…>> so you can tell what is his text and what is mine.

Cheers,

David

******** MY INITIAL EMAIL (EDITED TO REMOVE
******** CURRENT IRRELEVANCIES

4 April 2007

I have just learned from Norm Chonacky that you will be one of the participants in the PICUP WORKshop at Argonne, which is now only a month away, and I would like to begin a conversation about the contribution of Group 3, the group in which you have agreed to participate and that I have agreed to convene. As you probably recall from the invitation, Group 3 is to focus on designing one or more prototype computer-based modules that could be used in an intermediate or advanced course in electromagnetism, perhaps as homework exercises, perhaps as in-class presentations, perhaps in some other ways. If you have not already done so, I suggest that you look at the PICUP web page

http://CompPhysEd.shodor.org

and, in particular, that you look at the paragraphs following the tentative schedule that comes up if you open the link to the provisional agenda/schedule. Those paragraphs describe the expectations we are placing on each Work Group more fully than I have here.

With this email, I would like to start a discussion among the four of us that will perhaps lead to the identification of a number of possible topics for the modules we develop and, maybe even more importantly, to the identification of a number of broader questions whose answers may influence the detailed structure of the modules. For example, I think in broad terms that we ought to think some about how to balance using a computer to learn about some physical system and using some physical system to learn about computers. On the one hand, an approach that focuses on the physics without giving explicit---and in some cases fairly detailed---attention to the tool is, I think, in the end not completely satisfactory, since it risks developing an incomplete appreciation of the capabilities of the tool. On the other hand, an approach that focuses on the tool without leaning heavily on the physics for motivation is also not satisfactory, because it fails to provide the contexts in which the tool has application. In designing effective homework exercises and classroom components, I think we need to worry as much about how students will learn about the tools as we do about the physics that they will learn in the process.

By way of suggestions for possible topics of exercises, I am attaching a memo that I prepared a month or so ago and distributed to the members of the steering committee. There is nothing particularly profound in these exercises, and many can be done (tediously) without a computer, but I think they provide a basis for learning some physics while at the same time learning about the tool. Assignment of any of these exercises would require some prior discussion of the appropriate capabilities of the computational tool to be used.

I hasten to add that these exercises are merely suggestions. With this email, I solicit your beginning thoughts about possible topics for modules and also about broader questions that we should include for consideration in the meetings of our Work Group, once we all arrive at Argonne. I would like to have something of an agenda for our group laid out before the WORKshop begins so we don't spend too much of our valuable time together figuring out how to start. I would like to try to do that before we gather at ANL.

Further, if you already have exercises and/or modules that you would be willing to have linked to or mounted on the PICUP web site, please let me know.

As you probably both know, using computational resources in upper-level physics instruction has been a particular hobby horse of mine for decades. I am excited that steps are now being taken to try to speed the process of integrating serious computing into the undergraduate curriculum across the country. I am hopeful that this WORKshop and the activities that follow from it will constitute positive and effective steps toward the attainment of that broad goal. I thank you for your interest and for your willingness to participate---and I look forward to hearing your thoughts on the more immediate task that confronts our Work Group. I also look forward very much to renewing our acquaintance that started with your participation in my workshop at Lawrence several summers ago.

************* FROM JAN TOBOCHNIK 6 April 2007

E&M I think might be one of the toughest subjects to make a real impact at the undergraduate level because the principle goal of the course seems to me to teach what a field theory is all about and to help students become more proficient in solving pdes and doing vector calculus. Of course all of these can be done on the computer, but then we have to be careful to make sure that the students don't lose out because too much is done for them. However, there is also one opportunity and that is visualization, which seems to me to be more important in E&M than just about any other topic in physics. My experience in stat mech is that talking about algorithms contains a great deal of physics. I gained a great deal of understanding of what probability and the Boltzman factor was all about by learning the Metropolis algorithm. I think the same may be possible for thinking about visualization algorithms in E&M. Up until relatively recently visualization was too computationally intensive, but I think computers accessible to students are now fast enough that it should be a key part of what we do.

********** FROM MICHAEL GRAY 6 April 2007

I looked at your exercises and I am happy with using something like them to design a module around. But what would be very helpful to me in understanding what we need to do in the WORKshop is a clearer picture of the items below.

1. expected size of the WORKshop module: are these modules intended to be the size of, say, one class session and its attendant presentations/student assignments, or are they to be larger, covering an entire topic area in E&M. For example, your first exercise would be very good for a student assignment after the first class on the Lorentz force.

<<In a short WORKshop, we certainly can't complete very large modules, though we might be able to identify topics and sketch out what several modules might look like when they are finished. Probably we will want to spend some of our time talking about pedagogic strategies without focusing on too narrow a topic, at least initially. We would like to have something concrete to show for the couple of days of effort, but it is probably unrealistic to imagine that we will polish any module to perfection. As I said in my initial email, I also think we need to give some attention to the ways in which we teach our students to use computational tools, a task distinct related to but also in many ways distinct from the ways we have them exploit those tools to learn physics.>>

2. number of WORKshop modules: are we trying to develop just one, high-quality draft module, or are we aiming for a set of draft modules covering a significant part of an E&M course?

<<I may have included a response to this question in my response to question 1. We won't in the WORKshop have time to polish even one module. I would be happy if we can identify the outline of one or more modules, but I doubt we will be able to cover an entire course. We need to decide early on in the WORKshop (if not before we arrive)

what subtopic in EandM we will focus on. I think the planners also hope that the WORKshop will provide some stimulation that will prompt participants to develop modules further once the WORKshop is over.>>

3. the computational background expected of the students: this goes to your comments on the need to balance the need for teaching the physics with teaching the computational tools. I recently taught an intermediate class in E&M and wanted to include some computational work, but the low level of computational preparation in the students discouraged me because of the excessive time I would have had to spend preparing them.

<<I agree that we need to be clear about what we expect students to bring as background to each module. Perhaps the format for the presentation of a module should identify that assumed background. The overhead in learning to use a computational tool can be an impediment to actually exploiting that tool in course work. As maybe you all know, the Lawrence answer to this issue has been to modify the intermediate mechanics course so that about 40% of its time is spent directly on the capabilities of computational tools (IDL and MAPLE in our case). In large measure, the examples come from mechanics but the focus is on the tools. This arrangement seems to be working quite well for us, but I would be the last to contend it is the only way—or even the best way—to address the challenge.>>

4. the computational background expected of the instructors: instructors often struggle to minimize the overhead in preparing their classes, so an important part of the module may be the instructor materials. A well-done instructor packet may induce some instructors to use the modules while a packet requiring them to learn more about computational methods may cause them to pass up the module.

<<Good point. The existence of detailed solutions to exercises that are assigned as homework is critical for instructors who aren't themselves adept with the computational tools. So modules may need to be accompanied by such resources for the instructor. I do think, however, that this issue will become less important as we move to the future, if only because our younger faculty members are already much more receptive to using computational resources than our more senior faculty members.>>

Incidentally, a goal that I have in my computation-based classes is to show the students how numeric methods can take them further than analytic methods when dealing with ill-conditioned geometry or equations too difficult to handle analytically. Since our textbooks usually focus entirely on the classic analytic methods, students sometimes come to believe that everything is approachable analytically. Seeing examples of when hand methods fail gives them a realization of the advantage in knowing computational methods. This might be considered as a goal for our module design.

`*********** FROM KELLY ROOS   10 April 2007`

Sorry for the delay in responding to your email of last week, David. I've decided to disclose my zeroth order thoughts on the matter in order to contribute something without letting too much more time pass before responding. I plan to consider the tasks facing our work group further over the days to come, but here are some immediate ideas that I have regarding integrating computations into the traditional format of an E&M course. David, I have decided to not read your assignments memo until after I have written this so that I could come up with something close to original. I did however read your's and Jan's email messages, and concur wholeheartedly with the concepts of giving equal emphasis to the physics and the tools used in the computational solution to a particular problem, and that E&M provides an excellent opportunity for students to explore visualization of a field, and to learn computational visualization tools.

The first assignment I would have the students do would be to model a classical H-atom, even though it could technically fall under the classical mechanics category since the physics is the same as the 2-body planetary motion problem. Depending on the students' level of computational experience they may or may not have done this particular problem before. If they haven't seen it before, it would serve to warm them up to some of the concepts in computational physics; in particular, the simple application of the first order Runge-Kutta method and learning to develop some programming savvy, or the nuances of a particular commercial software package. By the way, I have extensive experience integrating computational assignments into classical mechanics and statistical mechanics, and my style has been to require the students to program everything with a language such as FORTRAN or C. This approach usually requires a significant effort on my part in providing extra training to get the students to the point where they are sufficiently competent to carry out the programming on their own, and on the students' part in dedicating themselves to learning the language on top of the other analytical requirements for the course. This brings me to a specific question I'd like to pose to the group: what computational vehicle should we advocate--direct programming, or a commercial software package, or both? I suppose that visualization of a field would best be accomplished with an available software package.

But even if the students have done the Kepler problem computationally before, I would still have them do the H-atom as a good review. And then, perhaps, have them "graduate" up to the more challenging mechanics problem of modeling a He-atom. Though it would be essentially a 4-body problem in mechanics, there is the extra interesting phenomenon of 2 sets of different charges interacting (there is only one kind of mass in the gravitational multi-body problem).

After the H and He-atom warm-ups, until the point in the semester is reached where the students learn about solving boundary value problems, I think the best integration of computational physics into the E&M course would be through the visualization concept that Jan mentioned. There, of course, are many problems involving the field produced by different charge distributions. These are perfect candidates for using the computer for visualization.

The following is a short list of computational assignments I would suggest for boundary value homework problems or classroom demonstrations:

- Solve Laplace's equation numerically (introduce the Jacobi method, or some similar relaxation approach for solving a partial differential equation) for a particular boundary geometry, and then create a 3D visualization of the resulting equipotential lines and field.

- Solve Poisson's equation for a particular charge distribution and set of boundaries, and then do the associated visualization.

- Calculate the magnetic field of a solenoid (introduction to numerical integration), and produce a view of the 3D field.

- Calculate the magnetic field of a particular complicated current distribution, and produce an image of the field.

Over the next days I hope to have a chance to play around with some actual numerical E&M problems and see what I can come up with. And David, I promise that I will now go back to your assignments memo to read and consider it fully.