Some dialogue (and FAQ) about the tutorials and clicker questions in Phys 2
Tutorials and peer instruction (i.e. clicker questions, or "Concept Tests" in class) are a very important part of Phys 2, but also a rather unfamiliar way of learning for a lot of students. During the time that we've used them (many years now) we've gotten a *lot* of positive feedback about them. It's clear that the majority of students are getting a lot out of these methods (for which I'm grateful!) But many students still wonder - what's the deal with them, why do we use Tutorials, why do we spend class time on peer discussion and voting? Here are a few brief comments, which might help you understand why they're so beneficial for so many students. If you want to chat more, please feel free to contact me. I'm going to focus more on the Tutorials here (which are often more difficult for some students to get used to) and will let *you* think about how most of these ideas carry over to the ConcepTests in class.
This page is long - just look at the "bold" headings, and read about what's bothering (or interesting you)

Tutorials are based on decades of Physics Education Research: They originally came from the physics education research group at U. Washington, who spent years interviewing students in their Phys 1 and 2 courses, learning about common student learning difficulties and how to help tackle them. These Tutorials were then constructed, studied, and revised over many years (almost every week's Tutorial is the result of roughly a third of a PhD student's thesis)

One goal is for you to do as well on post questions as our *physics graduate TA's* do on "pre" questions, and we exceed that goal regularly. So, they really work. In Phys 1, our learning gains on nationally normalized post-tests are typically 2-3 times higher than similar courses at comparable universities which do not use Tutorials. (including the occasional terms here at CU that haven't used them, which was the case when we first started) In fact, there is almost NO school in the country posting significantly higher normalized learning gains on conceptual questions than we are. In Phys 2, where the material (and post-tests) are tougher, we are doing about double the national averages for traditionally taught courses.

Tutorials emphasize concepts and sense-making: As you've surely noticed, we care a lot about problem solving and math skills in the course, but we care even more that this physics make *sense* to you! Online homework tends to emphasize the former somewhat, Tutorial (and Concept Tests) more the latter. But they also tie together! Look again at the online homeworks, you'll find many places where working through the Tutorials makes those problem easier and/or more relevant. And look at what we care about on the exams - there are a lot of questions (including multiple choice) which are more about making sense of the physics, and being able to extract key ideas and apply them in somewhat unfamiliar ways. That's the Tutorial emphasis, and that's what physics and engineering is ultimately all about. It's far more about explanation and reasoning than it is about computing numbers or manipulating symbols (despite whatever alternative impression you may have - talk to any working scientist if you're still skeptical :-)

Tutorials emphasize discussion and scientific behavior: When employers are surveyed regarding what skills they want college graduates to bring into their workplace, the top ten involve skills in communication, teamwork, and reasoning... Tutorials mimic the scientific process much more than lectures do. There is no more "lecturing" or "online homework" once you graduate and start *doing* science or engineering (or business, or law, or...) but there WILL be small group activities where you puzzle over problems, argue and discuss, try to figure out what's going on. These are learned skills, everyone gets better at them as they practice. If you're in a passive or quiet group, fire up your partners (or, if you prefer, switch groups) Ask questions, look for puzzles, go beyond the questions being asked by us. Try to make sense of this material, this is a great opportunity, take advantage of it. Having the TA and LA around for support just adds to the benefits- their job is to facilitate your conversations.

Learning comes from YOU, it is not something "transferred into you". This is true of all higher-level learning, not just physics. Some people get through high school with a sense that learning is about hearing (or reading) something, memorizing it, and repeating it back. That "it" might include an algorithm or method for solving problems (so, that would mean we tell you how to solve a kind of problem, and then you go do it). But I'm afraid that's only true of the very lowest levels of human learning. That approach will rapidly start to fail to suffice at CU (and beyond.) Tutorials are designed to get you involved, it's up to you to figure out the material, convince your neighbors, work out the reasons rather than just the answers...

The best way to learn is to teach. This is perhaps the most powerful benefit of Tutorials (and concept Tests.) Solving the Tutorials on your own would be nowhere near as valuable as coming to class, listening to other people's ideas, evaluating them, and helping them to see how you are thinking about it. There is lots of published research demonstrating this. There are often many ways to think about a given question, and the more you think about connecting them the deeper your own understanding is. I don't know of a better way to learn than to try teaching something (and not surprisingly, the people with the highest normalized learning gains in this course are our TA's and LA's)

Some frequently asked questions about Tutorials I've gotten in the past:

- **Why won't the TA's just tell me the answer?**
  This is a response to our use of *Socratic dialogue* in tutorials. It's true that your TA and LA are not teaching in a conventional way, but don't be deceived. There is more *learning* going on in tutorial sections than ever happened when the TA stood by the blackboard and solved problems in front of people. (By a long shot!) What they're doing requires a lot of skill, and they are working hard at their teaching. They don't just come into tutorial and wing it. Their questions are not random, or useless, despite how it may occasionally feel. When they ask "well, what do YOU think"?, as often happens at first, they are not blowing you off - they want (and need) to know.

Remember, the whole point is for you to discover the answer. Being told an answer can help if it's a fact, but it does no good if it's a concept. In many cases, it's not so much just *about* the answer, it's about the *process of discovery* . (A specific example: the "uniform charged rod" vs "point charge" exercise in the first tutorial - the point was not for you to memorize which one makes a larger force, it was for you to figure out for yourself why that's true, so that when we talk about, say, finding the field from more interesting and realistic charge distributions later on you'll have a sense for what contributes, and why, and how. And, when we go beyond electricity, to e.g. magnetism, you'll be able to generalize the result to distributions of *current* much more easily) We do lots of different things in this class - you have a text which does just give you straight answers, you have lectures which are a mix of answers, and some discussion… but ultimately, you still get lots of that sharp feedback. (Same, even more so, with online homework) So the bulk of this class *is* indeed designed to give you straight answers. But tutorial is different, and intentionally so. This is the opportunity for you to stretch. To figure out something new, and useful, for yourself. To decide "how do I know if I'm right, *besides* asking some authority?" This is something you absolutely need to learn - more even than learning Maxwell's Equations! It's not easy, and we're trying to provide a scaffold here to get you started. You have your peers to talk to, an LA and TA to help, and of course all the other resources of the course. But take advantage of these 50 minutes to figure things out for yourself, without just being told answers.

- **But I DO already know this stuff, why do I have to do it this way** ?
  Every week, our TA's and LA's (who "already know this stuff" quite well) do the Tutorials a few days before you do. We spend about an hour and a half, rather than 50 minutes, because we start arguing, puzzling, thinking about other ways to think about it, wondering what sorts of ideas might be out there that you will bring into the Tutorials. It's a blast, and every week, we walk away realizing that we understand this stuff much better than we did before. Our LA's have been through this course themselves, most of them just last term. They *really* appreciate how much more there inevitably is to learn, even (especially) about the most basic and important ideas, which is what the Tutorials zoom in on. If you feel you are already the master of this material, take advantage of this chance to teach your fellow groupmates, and see how much *you* get out of that! Even I get tripped up every now and then on a Tutorial question, where I realize that although it may look simple, it turns out it was after something very deep, or rich.

  On a similar point - some students feel that Tutorials are occasionally too repetitive. And yes, sometimes they do come at an idea several times, but it's never busy work - if the question looks the same as a previous one, think about it some more. Something is different, there's something interesting, challenging, or subtle at play here - discover it!

- **If we don't already know it, how can we learn from a Tutorial**?
  It is true that the tutorials sometimes contain material which is not exactly *familiar*. (This may happen more often later in the term) Tutorials are designed to push a little - to give you something that you *are* equipped to answer but have not necessarily seen before. For example, we had you thinking about flux before we had formally covered Gauss' law in lecture. Having discovered and made sense of the result, e.g. what d(Area) might mean, the lecture that came next likely meant that much more to you. Real learning is not about memorization or template matching (i.e. "plug and chug") You really do have the knowledge, and the skills, when you walk in the door. The questions are meant to push you a little, to help you discover knowledge rather than simply be presented it. This is, ultimately, what you need to go on in this, and more advanced classes, to do research, to design, to do just about anything in science and beyond!

  One last thing on this - if you are REALLY struggling in the tutorials, you might find it worth your while to spend a little time preparing for them. Take a look at it in advance, it might allow for the tutorial to be that much more productive, and well worth the small extra time in advance if it means getting through the tutorials with more confidence and ease.

  And on a similar point - some students feel that Tutorials are occasionally too vague. Indeed, when this happens it's *usually* intentional. Science is vague, nobody tells ME what questions to research, we spend as much time in my research group trying to figure out what question we're trying to answer as we do answering them. This is an essential part of science, and one of the hidden learning goals of the Tutorials.

- **I hate working in groups, this isn't my "learning style"**.
  And yet, there's probably not a single person in this class who will not have to work in groups for the rest of their life. Working in groups can be frustrating, and challenging. It is also rewarding, and productive. There is a reason that engineers and scientists work in groups - you achieve more, the whole is greater than the sum of its parts. If you think of yourself as solitary, consider this a valuable opportunity to begin to explore how a group can help you. When the other people are slower than you, that's not a problem - it's great. There is no better way to learn than to teach. Take advantage of it! And, if instead your group is way ahead of you - slow them down. Be assertive. Make sure they bring you with them as they discover the physics. You are free to change groups - find/make a group that fits you best. This is how science is done, at all levels beyond the very beginnings - and that's why we're doing it here too. When your group starts to click, it's an amazing experience.

- **Maybe you could post answers?**
  This is closely related to the first question (why don't the TA's tell you the answers?) But with a twist - can't we get the answers AFTER we've wrestled with them on our

own? But, what we said above still applies. You can, of course, always go one-on-one with me, or your TA or LA, and really get definite feedback if you need it. (Please feel free to do so) But, *posting* answers is very destructive to this process, because once I post answers, most people get the wrong message. That the ANSWER was all that mattered. That's not what the tutorial is after - we're trying to get you to figure out how physics is science - how can you convince yourself that something is correct or not? You will get feedback, through the graded tutorial homeworks. So, although I will post answers to everything else in the class (there's tons of direct, fast feedback. From example problems in the text and my lecture notes, to online homework's instant yes/no, to the concept tests in class and posted on the web), I prefer not to do so on the tutorials. Tutorial problems are carefully designed to be something you can do, on your own, and check/make sense of them without needing someone to say yes or no. You can convince yourself! That's why they may sometimes look repetitive - that's not busy work, that's modeling how you check yourself.

- **I don't see how the Tutorials help with the online homework.**
  Indeed, the homework system is a somewhat different kind of exercise. Those questions (which are basically end-of-chapter textbook problems) are important, but are not solely representative of what *doing physics* is. Many people have been trained (by high school) to think that homework questions is it - if you can do those, you know your stuff. (It's what people who give standardized tests want you to be able to do, and so we learn that.) But this belief is too simple - the tutorial hw and concept questions are something much deeper. It often looks easier (because there's not so much math involved), but generally it's harder, and more important. To explain your reasoning, to use concepts to go to unfamiliar cases... That's the good stuff, it's what physics (and science in general) is all about. Online and tutorial hw count roughly equally, but they aren't meant to duplicate each other, or be redundant - they carry different learning goals with them. And of course, they are still much more than marginally related – online homework takes the exact same physics concepts, but asks you to make it mathematically rigorous. Tutorial asks you to think about reasons, and solve more conceptually rich problems. Both are important, both are connected (but I agree, they are different.) If you start to look, you will find many homework problems are essentially the same as a tutorial problem - at least, if you can look past the surface. I do sometimes wish both our homework and the tutorials would be a little more real-world focused (they use a lot of "point objects" and "infinite sheets" which might perhaps make it feel a little tedious and disconnected from life) but of course you can do the generalization - point charges are metaphors for electrons and protons, or even a balloon sticking to the wall, and the capacitor in your camera or flash memory really does look like an infinite sheet to a little electron nearby.

- **I just don't think Tutorials are right for me.**
  What we've discovered (with a lot of data collection over many years) is that there is

more *learning* going on in tutorial sections than ever happened when the TA stood by the blackboard and solved problems in front of people. (By a long shot!) This is true across the board - it's true for the students who struggle, and also the top performing students. Some of our best tutorial learning gains (using these exact same materials) have occurred in advanced honors physics classes. The results have been consistent across different universities, in different class sizes, with very different populations. These things work! To date, I know of no recitation section taught in a conventional way, or even a partly conventional way (i.e. some lecturing, and some tutorial) that has shown the documented learning gains of these student-centered tutorials. There are inevitably some students who (especially at first) are suspicious, who think "it's not working for me". And yet, consistently, those students' learning gains are high too. So have faith! It helps a lot when students go into tutorial with a positive attitude.

I care a lot about students enjoying the experience of learning - I really think it matters. You do need to participate and help each other. You need to be patient (when your TA/LA is busy), but assertive (to get them to come talk to you as often as possible) Don't expect them to give the answer - their job is to help YOU figure out your own path through this material. Being asked questions instead of hearing answers can be very frustrating at first, but when you think about what they're asking, and try to answer them, you will discover you understand a great deal more than you ever thought.

There's a lot here. Hope it helps a little, so that you can make tutorials more productive (and fun) for yourself.