Some notes about math in INS for Paula and David

I see that I've done this program six times in its various manifestations, so I have some experience to share with you.

INS is generally listed with a prerequisite of high school algebra. On the one hand, I think it's important to insist on that as a minimum; on the other hand, I'm not sure it makes a lot of difference. Michael Beug once pointed out that the equation the students can't handle is

$$x = y/z$$

That is, even though they've probably all been through algebra, they are so inept that they can't convert into equivalent equations--to solve for y or z, in other words. (I believe it was Jeff who once heard a high school physics teacher talking about the three fundamental equations of electricity: V = IR, R = V/I, and I = V/R. So you can imagine the competence of some of the teachers they've had!) I have a partial cure (workshop material) for that elementary problem, but you should still expect to run into it, and it may frustrate hell out of you.

Last year in INS was very different from other experiences I've had, and the math aspect of the program was bad. A couple of years ago, we tried a kind of collaboration with a couple of Core programs in which Rob Cole was teaching some math via a computer program, and that was also bad. I strongly believe you must develop some core mathematical-scientific concepts, as listed below, and also follow the principle of dividing the class into groups on the basis of the level of mathematical competence that they arrive with, ideally into three groups: those with mathematical difficulties, those who are ready to do college algebra (precalculus math), and those who are just about ready to start calculus. When I did INS once with Clyde and Byron Youtz (physicist and founding faculty member who died several years ago), I took the bottom group, Clyde the middle group, and Byron the top group. When I've done the program with Clyde, Jeff, and George Dimitroff, I've again taken the lowest group and George has done two other groups; one year, we got another fellow to take one group, but one person could really handle two groups. I believe you will have to use the former method, since you don't have one person to do nothing but math. (I'm assuming David will teach physics.)

It is important for everyone to cover at least the following topics as early as possible:

exponential notation and arithmetic
order-of-magnitude reasoning (use Fermi problems)
the metric (SI) system and its manipulation
unit conversions
rate problems (variations on distance-rate-time thinking)
graphing

You may be shocked to think that college students interested in science don't know all this, but be prepared for the shock. They typically don't. Those who are most advanced in math may not need any of this, but don't assume anything.

It is also important for the math groups to provide some support for the more mathematical aspects of the science, especially the chemistry. This is particularly true for students in the lowest group, as you might expect. Since I've always taught that bottom group, I've spent considerable time helping people with simple reasoning in science; that includes many of the

topics I listed above, but it extends to such matters as reasoning through stoichiometry in chemistry, which is a particular application of unit-conversion thinking. I sometimes feel that I spend about as much time teaching chemistry as teaching math.

When you finally get past the most elementary mathematical matters, you will start getting into the standard topics of precalculus math. One point to emphasize is learning to think about functions, and I believe it is especially important to develop a graphical sense of the various functions; I urge you to pick books that emphasize functions and graphing. In this context, I'll show you a book that we finally used last year that may do the job well; after letting the students go through kind of half-assed math during the fall and winter, we finally did a straightforward math class in the spring, using the book *Functions Modeling Change*. It covers all the right topics in quite a nice way, and it does get into trigonometry, another topic I think is very important to cover.

I have a ton of material (exercises, tests, explanations) that I think you'll find useful for teaching a lot of the math, and I'm happy to share it with you. I also have some old self-paced learning units that I wrote long ago on topics such as exponential notation, logarithms, and the metric system. Self-paced materials are no longer in vogue, but students find these very helpful. My way of introducing logarithms may even be new and useful to you.

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