



# So You Wanna Be an Astronomer?

by Selby Cull, Hampshire College

*Selby Cull is a Science Journalist with the Journal of Young Investigators.*

Ten o'clock at night, bent over physics book, notes, and calculator, and trying like mad to visualize Gauss's Law, you're thinking: "When am I ever going to use this?" You wanted to study galaxy formation, search for life in the universe, and peek into the racy lives of binaries. Instead, you're writing out problems two through 98 (even) from the "Challenge" section of your physics textbook.

Will your first research project as a degreed astronomer be one big problem set? What parts of your undergraduate education will you actually put to use, and what parts will have vanished after finals?

The answer seems to be in grounding: the mind-set and problem-solving skills you start to develop as an undergraduate, the basic understanding of the subjects and ideas that go into astronomy. "The techniques of problem solving -- learned from those pesky problem sets -- and the mental dexterity and tenacity are valuable," comments astronomy professor Eric Rubenstein of Smith College.

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"I still use just about everything from *Halliday and Resnick*-type basic physics," says Five College astronomy fellow Doug Leonard (*Halliday and Resnick* being a popular introductory physics text). "A firm, broad background in the basics is essential, since you never know what arcane specialty you'll wind up in!"

So Gauss's Law is a must.

**A calculator and a math book tucked under your arm**

In order even to start in physics' general direction, you're going to need a calculator and math book tucked under one arm.

However, while advanced calculus and differential equations are definitely helpful, they aren't necessarily the everyday tools of the astronomer. "I use a bit of linear algebra and vector calculus, but usually nothing too severe," says Leonard. "I can't remember the last time I had to solve an integral."

"For experiments, problem-solving skills in math are great," says Simon Radford, an astronomer with the National Radio Astronomy Observatory. "Exposure to math proofs as an undergraduate can be beneficial too, but mostly for work in theory. With experiments, you don't need to prove the Pythagorean Theorem every time you want to use it, but it still works pretty well."

Statistics are another matter. Most science students believe statistics lie firmly in the realm of the economist; however, its reach extends far enough into astronomy to make it a necessity.

"Statistics are a vital part of doing any type of empirical research," emphasizes Leonard. "Yet they are rarely included in the standard curriculum ... I might spend a week gathering data, and six months figuring out where to put my error bars."

## **Programming - the most important tool**

Aside from knowing *where* to put the error bars, it is essential to know *how* to put in the error bars. Drawing them in by hand is a ridiculous option, so computers are the only way to go. Computer programming is "absolutely essential," according to Rubenstein, and "absolutely critical," according to Leonard.

"Programming is completely integrated into just about any astronomical research," continues Leonard. "Whether you are manipulating data or solving radiative transfer equations, it is easily the single most important tool to have in your toolkit."

But what do you do with a tool that has so many attachments? Programming languages abound -- C, C++, Fortran, Perl, python, c-shell, LISP... the list goes on. Fortunately, it's the basic skills of programming that are needed, and these are easily learned at the undergraduate level.

"The fads of programming come and go," says Radford. "But the underlying structures are the same -- procedural algorithms and such. Perl and scripting languages in general are useful and adaptable."

"You can't do a thing without computers," he adds.

## **Where is the time for actual astronomy?**

Peering at their schedules at this point probably leaves most astronomy students at least a

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little frustrated. In between physics, math, statistics, and computer programming courses, where is the time for actual astronomy? “There’s a lot of delayed satisfaction if your heart loves astronomy,” remarks Leonard. “The best preparation is to study physics, math, computer programming, statistics, even chemistry and biology. Astronomy comes after all of those. It’s good to occasionally take an astronomy course, just to remind yourself of why you love the field, and why it’s worth it to take all these ‘other’ subjects to ultimately work in the field that you’re really passionate about.”

Fortunately, there are plenty of opportunities outside of coursework to remind yourself of why you’re proving endless math theorems. Research opportunities for undergraduates are abundant, if you’re willing to spend the time to look for them. Research Experiences for Undergraduates, funded by the National Science Foundation and run through various universities and institutions, are an excellent start, and there

are probably well over 50 summer research programs for undergraduate astronomy majors.

“[Research experiences] are essential!” says Rubenstein. “Doing problem sets will neither prepare you, nor encourage you, to enter a life of scientific research. Research is fun. Problem sets are problem sets.”

Of course, most research positions (even the short summer ones) are full of hard work. “The main thing that most students discover is that there’s quite a lot of ‘grunge work’ that is involved before you get a ‘result,’” cautions Leonard. “‘Eureka’ moments are generally few and far between.”

“The most important thing is to pursue a career in science because you’re interested in it,” says Radford. “Are you going to get a \$1,000,000 a year salary? Not a chance. A Nobel? Long shot. A rewarding and challenging job? Yes!”

### **Web sites related to this topic**

[NASA listing of internship opportunities](#)

[Carlton College's listing of summer internships](#) -- an extensive list of astronomy and physics-related research opportunities

[National Science Foundation's Research Experiences for Undergraduates Homepage](#) -- a small listing of some of the available REU's, but there are many more out there

[Summer Opportunities for undergraduates, graduates and post-docs from the American Astronomical Society](#)

[Careers in Astronomy Page from the American Astronomical Society](#) -- an excellent page describing education requirements for future astronomers

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*Selby Cull is studying planetary sciences at Hampshire College. She may be reached at [cull@jyi.org](mailto:cull@jyi.org).*

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