PHYSICISTS IN FINANCE

Though the challenges of "quantitative finance" are diverse and often exhilarating, success for the erstwhile physicist is not at all assured. What factors are involved in making the transition to finance?

Joseph M. Pimbley

To a physicist facing significant difficulty in the job market, the allure of a career in finance is obvious: The industry has numerous opportunities that demand the physicist's quantitative skills, and pay handsomely for them. Those contemplating such a move, however, need to look beyond these immediate considerations, for the culture of finance differs markedly from that of physics, having different goals and philosophies, work styles, even dress codes. To be successful on Wall Street, the physicist must willingly adapt to Wall Street's ways.

To add precision to the phrase "physicists in finance," I am using "physicists" to denote PhD recipients and "finance" to refer to the disciplines that require the greatest mathematical and computational skills, such as derivative pricing and construction, risk management and investigation of trading strategies. It is somewhat unjust to exclude physicists who have not reached the PhD level, since many issues I discuss will be just as relevant for this group. But PhD physicists who move to finance clearly repudiate a greater number of years of training and are therefore more interesting to study. In fact, a man or woman who earns a BS in physics and then completes a master's degree in business administration (MBA) has not necessarily changed career plans. Rather, such a path can be a shrewd choice for success in the financial industry.

The status of physicists in finance

There exists no definitive count of the number of physicists in finance, since there are no surveys or professional bodies that track this population. In fact, it's likely that few financial firms have sought to count the physicists they employ. Based on personal experience and observation, I estimate that the total number falls within the range of one hundred to one thousand, with hiring still very much a "nucleation and growth" phenomenon. Many companies have precisely zero physicists. Those banks and other institutions that have the greatest number of physicists tend to be fairly large and to have physicists themselves as the hiring managers. Finance, unlike physics, is geographically concentrated in several major centers—New York City, London and Hong Kong being the three largest—and physicists in finance tend to be found in those locales.

Physicists in finance tend to have little experience in physics. The typical case is that of a person who moves directly into finance following graduate school or from a postdoctoral position. Less common are the émigrés from full-time "legitimate" physicist positions. Certainly this observation implies that one cause of the physics-to-finance transition is the shortage of jobs in physics, especially for those just starting their careers. But it is regrettable that younger physicists, who have not had the opportunity to explore their chosen disciplines and their abilities on their own, are more likely to shift career goals. Older colleagues, by contrast, have orchestrated successful research projects with lasting contributions, and are therefore much better equipped to contemplate leaving the physics profession. They know what they are forsaking and how their philosophies will change.

Although scientists and engineers consider themselves technical people, "technical" has a different meaning on Wall Street. "Technical analysis" entails poring over graphs of, say, stock prices versus time and divining parameters such as "support levels," "barriers," "momentum" and "head-and-shoulders patterns." Such concepts are meaningless, if you abide by the so-called efficient market theory, which states that perceived patterns in historical data do not predict future performance. So it's actually good news that physicists in finance are not "technical."

In the financial industry, physicists, along with other scientists, engineers and mathematicians, generally apply their skills to what is called quantitative finance. For that reason, such people earn the nickname "quants." Another sobriquet is "rocket scientists." Frankly, these are not terms of endearment. They are mildly disparaging labels that tend to distract the listener from fully perceiving the value added by physicists. Unfortunately, many physicists willingly comply with this pigeonholing. This is true not only on Wall Street but throughout society. For reasons unfathomable, physicists accept, and perhaps enjoy, being considered rumpled, eccentric and prone to irrational bursts of intellectual energy.

The value of physicists

At the most general level, physicists have a universal goal of understanding deeply whatever they are studying. It is this ultimate deep comprehension that renders physicists so valuable to finance (see PHYSICS TODAY, April 1994, page 55). Professionals from other disciplines, by contrast, often do not share this goal of deep understanding. Mathematicians, for example, focus invariably on the mathematics; they have little interest in formulating real-world problems in mathematical terms, or in interpreting and explaining their solutions. And so they tend to live in the middle step of deriving solutions (analytical, approximate, asymptotic, numerical or whatever) to a set of

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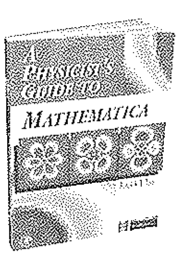

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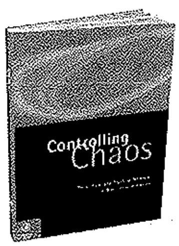

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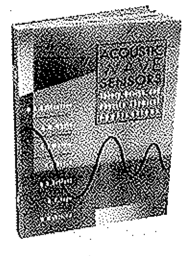

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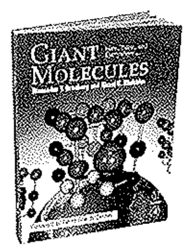

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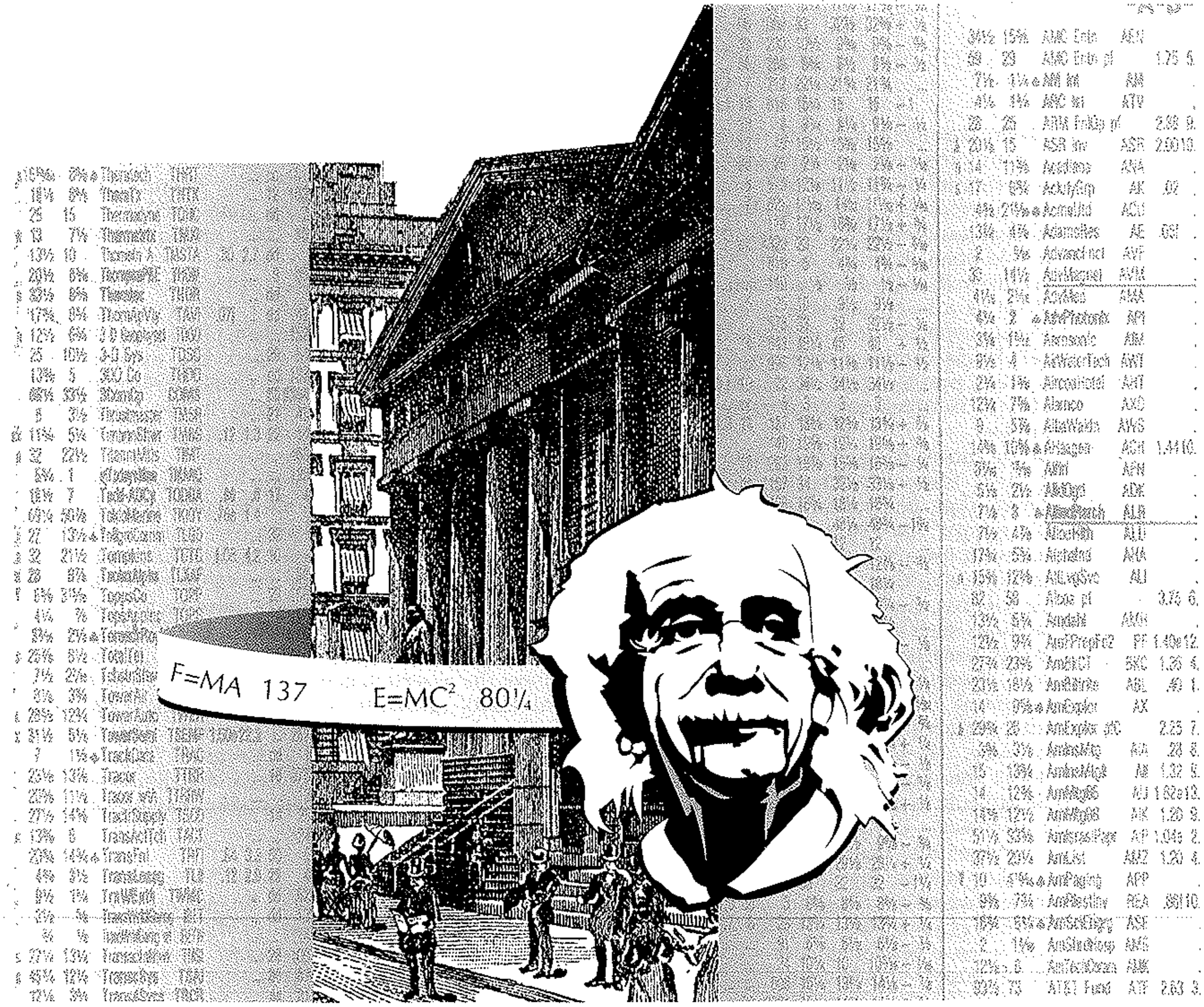


equations with auxiliary conditions.

Nevertheless, the typical physics curriculum has absolutely no content relevant to Treasury notes or foreign currency prices. So how can physicists make valuable contributions in finance?

It is certainly possible to learn the core elements and jargon of finance on the job. The time scale of the learning curve is highly dependent on the new employee's environment; some positions provide exposure to many financial products and processes, while others are more narrow. The financial novice can expect to be productive within six months and ready for more responsibility within a year.

Beyond their ability to learn quickly, physicists are problem solvers. They excel at identifying core issues and approaching and solving them in a disciplined manner. Their research training translates into a strong ability to conceive, implement and manage long-term projects. What's more, physicists have the ingrained habit of thinking fundamentally and deriving solutions to problems by reference to core principles. Few others in finance have this mindset; instead, they have been trained in memorizing methods and applying software tools. The physicist's strength is that he or she can confront a new problem and see quickly how to solve it without benefit of existing methods or software.

Consider the Black–Scholes equation[1] for the value of an equity call option as a function of the equity value x and time t:

$$\frac{\partial w}{\partial t} = rw - rx\frac{\partial w}{\partial x} - \frac{\sigma^2}{2}x^2\frac{\partial^2 w}{\partial x^2}$$

This linear partial differential equation (PDE) with its boundary and initial conditions admits a straightforward solution after a few variable transformations. A physicist studying equity options would learn to derive and solve this equation and the auxiliary conditions. A new financial "product" might require only minor revisions to this system. But the great majority of financiers do not know calculus (to say nothing of linear PDEs).

It is worthwhile mentioning what physicists do not bring to the finance world. Despite some news reports in recent years (see, for example, PHYSICS TODAY, May 1995, page 55; March 1996, page 15; July 1996, page 90), we are not alchemists who find the secrets to reaping quick profits. Although some people do believe it is possible to study past market data (such as commodity prices) and determine hidden patterns by spectrum analysis techniques or whatever, I am highly skeptical. There is no reasonable argument or scientific evidence to support the existence of such "beat-the-market" patterns. Neither do I believe that the application of chaos theory, fractals or neural networks will ever produce trading profits.

Employment and financial incentives

Among the many factors to consider in electing to pursue a financial career, perhaps the most transparent are the prospects for employment and monetary compensation.

The traditional occupations in physics research and education are, of course, deeply satisfying careers with low stress and a high level of personal autonomy. Permanent positions are reasonably secure and pay good salaries. What's more, society holds physicists in high regard.

But as has been documented by the American Institute of Physics, many physicists are struggling in the job market, with a substantial percentage of young physicists stuck in postdoctoral positions as well as temporary, non-tenure-track teaching assignments. One could claim that postdocs provide additional training to enrich one's early career. But conventional entry-level positions as an assistant professor or as a staff physicist in industry also afford great learning opportunities. In fact, all physicists in all posts at all levels continue to learn and sharpen their skills. As I see it, postdoc positions are nothing more than temporary berths in which qualified applicants await real job opportunities.

In looking at the causes of the employment imbalance in physics, one must also consider the impact of the government subsidy that generates physics graduates. Through research grants, the US government pays students to study and work toward their doctorates. Virtually all physics students receive this aid (as do their counterparts in the other sciences, mathematics and engineering). By contrast, disciplines such as law, medicine and finance do not enjoy this universal subsidy. Why do the government grants exist? Those of us who have lived in academia and written grant proposals realize that student education, not the research project itself, is the *raison d'être* for the largesse. It is the federal government's explicit goal to boost the physics PhD population.

And it is not difficult to see why. The atomic bomb, radar and other inventions developed by physicists contributed greatly to America's victory in World War II, and continue to play a key role in the nation's defense. The lesson the government appears to have internalized is that generating an excess of physics PhDs is sound public policy. Consider the policy to be a peacetime strategy for national defense, in which the supply-and-demand distortion in the market is a small price (for the government) to pay.

But while positions in physics continue to be in short supply, quantitative analysis positions in finance are not, and the typical salaries are well beyond those in physics. In the physics world, one's salary is a monotonically increasing function of time that saturates at about $100 000 per annum. By contrast, the entry-level compensation for highly educated (MBA, JD, PhD) professionals in all financial disciplines is not far below $100 000 per year. "Not far below" applies in both a numerical and chronological sense—that is, compensation increases quickly. A young person who begins at, say, $60 000 a year will generally hit six figures within two years; after that, salaries can vary wildly. It is not at all unusual to earn twice as much in a good year as in a bad year. Saturation levels are not as clear and, to the extent they exist, depend on the specialty. Quantitative analysts would likely not make more than $750 000 a year, but they can readily switch to other specialties with greater income potential if they so desire.

Year-end cash bonuses constitute the majority of many people's income on Wall Street. One's salary, which may increase only modestly from year to year, is the base. The magnitude of the bonus allows the employer to vary compensation in line with the firm's performance. But it also produces stress and anxiety in the recipients. Employees learn in one minute whether their boss thinks they had a great, or mediocre, year.

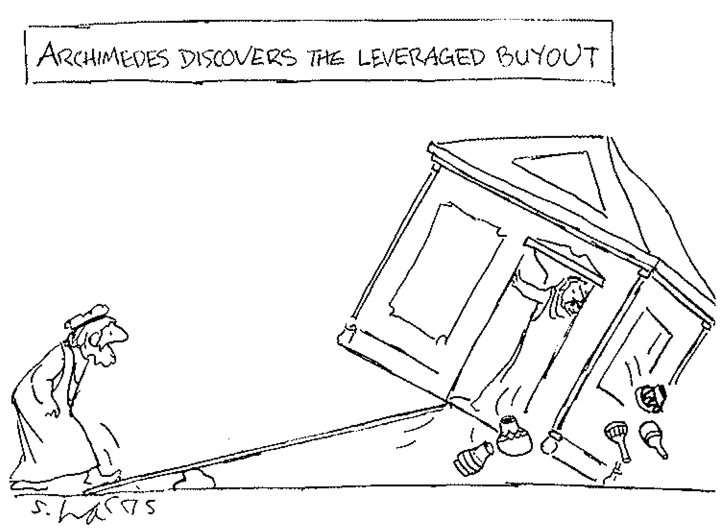
Why all the focus on money? Should one choose the job or career that provides the highest income? Of course not. But in a free society with free markets, the financial compensation of a profession is a measurement, admittedly just one of several, of the value of the profession to the society. Thus, physicists may serve society better when they pursue careers in finance. What an incendiary statement! Do I really believe it? Not really. But I do believe the assertion is worthy of debate. One could argue that many scientists place absurdly high potential economic value on their research projects. The counterargument might be that raised by Margaret Thatcher, who has observed that Michael Faraday's contributions are worth far more than the combined market capitalizations of all the companies in the UK.

Breaking in

How does a physicist move to finance and what is it like? The answer to the first part of the question is straightforward. There are surprisingly numerous entry-level positions for physics PhDs that require no prior knowledge of finance. Still, such posts may be difficult to locate; one will not find all positions advertised in one or two well-known trade journals. In fact, Wall Street employment is quirky in that it is much more challenging to break into the club than it is to move from one job to another once inside.

Though considered a detriment in science and engineering, executive recruiters, or "headhunters," play a key role in the financial industry. By all means, a job-seeking physicist should engage such assistance, keeping in mind that some recruiters are better than others. (Employers, not job seekers, pay their fees.) One should also know that although experience in finance is not absolutely essential to landing an entry-level appointment, it is extremely helpful. Added to a physics PhD, a little bit goes a long way. For example, gaining an MBA would be a winning addition to one's résumé, but ironically, as a quantitative analyst, one would not learn much of value from such a degree. Far more productive would be to obtain one of the recently created master's degrees in computational or quantitative finance.

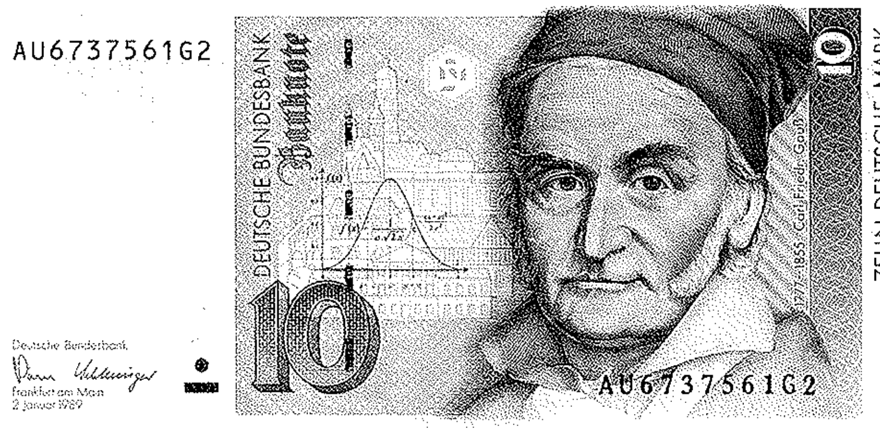
Now to the harder question, What is it like to work in finance? First the good news: The actual challenges can be remarkably similar to those in computational and theoretical physics. One is given a problem such as how to value a new type of option (a derivative financial product). To solve the problem, the analyst must translate the written description of the transaction between the buyer and seller into mathematical equations and auxiliary



conditions. The next step is to solve this system, analytically or numerically, and then interpret the solution for the benefit of the traders, financial engineers or whoever.

A minimalist interpretation of the solution would merely be the value of the option. But the analyst can and should go much further. He or she is now the in-house expert on how the option works, and so is in a position to advise the organization on how best to hedge (neutralize the risk of) the option and how to modify its terms to better suit a specific customer.

Hence, quantitative finance problems challenge the physicist to consider and solve real problems. One must translate such real problems into the realm of mathematics and then adroitly wield the mathematical scalpel to gain the desired insights and information. Good physicists make good quantitative financial analysts. Mediocre physicists, likewise, are mediocre analysts.



A PHYSICIST IN FINANCE—LITERALLY. Karl Friedrich Gauss (1777–1855) appears on Germany's 10-mark banknote. Also depicted on the bill is a graph of the standard normal probability density function, which plays an important role in finance.

Adapting to the new culture

The similarity of finance and physics ends here. Although physicists certainly have the ability to succeed in finance, they must be prepared for an entirely different culture. The aspects one notices first are those pertaining to appearance and work hours. Men and women on Wall Street are well groomed and wear expensive clothes—you become good friends with your dry cleaner!

Typical work hours vary somewhat with the company and with one's position and stature. Broadly speaking, ten hours a day is modest and may be adequate in some situations, but twelve-hour days are more common, and fourteen hours is not unusual. (Of course, such hours would not scare many graduate students.) The culture of long hours compels many employees to spend more time in the office than is necessary to complete their tasks. There is a disproportionate emphasis on long hours relative to productivity.

Many Wall Streeters have two to three hours of commuting each day, and those who are the parents of young children must sometimes construct elaborate child-care arrangements. In 1995, the president of Wall Street's most prestigious firm retired in his early fifties. Why would he do so when he had every expectation of spending many years in an enviable role? He explained that he hadn't been home when his children grew up, and he didn't want to do the same with his grandchildren. But many people in the financial industry buy into the idea that their careers take priority over their families.

Perhaps the biggest loss a physicist suffers in moving to finance is what I call the Isaac Newton goal. Physicists today study Newton's contributions of several hundred years ago and will continue to do so for centuries into the future. The ultimate goal of all physicists is to produce new and relevant insights whose value will far outlive them. Who would not want Ludwig Boltzmann's epitaph, $S = k \log W$?

In finance, there is virtually no history and no posterity. To the extent that individuals have made lasting contributions, the individuals themselves are forgotten. The Eurodollar futures market, for example, is of inestimable value to the financial world. Who conceived, championed and instituted this market less than 30 years ago? It doesn't matter.

There's no question that losing this thought of "working for posterity" is unsettling. One may wonder, Am I really working just for myself? Just for today? It's not that physicists ponder posterity consciously every day. Rather, they think about their much more focused short-term goals and their enjoyment of the endeavor. But I claim that a key element of that enjoyment is the connection of the project to the past and, with luck, to the future.

A final cultural difference that the physicist will encounter is the overt "win–lose" attitude that permeates finance. Many in the financial industry believe that their victory can come only at the expense of another's defeat, and the result is that there is a lesser tendency for peers to collaborate and exchange information than there should be. This attitude may explain why the financial industry places little value on leverage—that is, a person's attempt to place his or her skills at work for the company on a broader scale. For example, one may teach colleagues a technique or skill through seminars, reports or informal collaborations. Or one may write computer codes or spreadsheets and disseminate them to others. But such leveraging is neither encouraged nor rewarded in finance, and thus not practiced.

In physics, of course, leveraging is a way of life. It sometimes reaches the opposite extreme in which physicists wonder if they will see the fruits of their labor, since those may grow most productively in an unknown laboratory. Nevertheless, writing and teaching are excellent habits that physicists can and should bring to finance.

Ideally, physics is "win–win." There exists an infinity of undiscovered physics, and every new insight or discovery is meant to benefit all physicists. If one researcher does great work, it does not detract at all from what the person in the next laboratory is doing. In practice, of course, this ideal goes unrealized, particularly in academia, where funding disparities and political stature ride the coattails of perceived scientific achievement.

In fact, the scientific culture harbors a number of hidden "win–lose" drivers that erode the principle of scientific inquiry. Take the Nobel Prize. The prize is an inherent aspect of the physics culture, but it fails to stand up to scrutiny. Why do we need it? Why is there meaning in a small panel of judges declaring that research project X "wins"? If the project is so noteworthy, as it may be, then its enshrinement in posterity will be the true reward for the researcher.

What's the point of criticizing the Nobel? Only to show that there are negative aspects of any culture that are often difficult to divine from within. In this sense, the prize is much like the long hours, lack of leverage and absence of posterity in finance careers.

If one thinks further, one can identify other cultural disadvantages in physics. For example, there are many smart people in physics; the smarter you are the better. The respect others have for you increases according to your intelligence. But why? Being smart is no more an accomplishment than being tall. Compounding the misguided accolades to intelligence are those for eccentricity, which the physicists' culture promotes in subtle and generally harmless ways. The underlying message seems to be that physicists are different from the rest of society and that the difference should be publicized. It's really a mild contempt for everybody else. Of course, physicists try not to say as much when they ask for funding.

If Einstein were young today, he might be working on Wall Street. Unfortunately, he'd be so well compensated and so tired at the end of the day, he would never have gained such fame!

Success and failure

On Wall Street, the physicist's greatest strength lies in the ability and desire to gain a deep understanding of the fundamental principles and analytical techniques of finance. True mastery leads to the invention of new products and the potential to identify and manage new risks faster and more accurately than competitors. Mathematical manipulations and a scientific approach to the subject serve as the springboard for the physicist's expertise.

As is true in all life, there are more paths to failure than to success. If one is to succeed, the first and foremost element is one's focus on working with other people. This is not merely important, it is crucial. One must strategize on how best to explain one's ideas. What does not work is to flash around your mathematical demonstration that, say, long maturity floating-rate notes have the market risk of short-term instruments. Equations and their mutations from one line to another have no credibility.

In other words, physicists cannot speak their native tongue when explaining and listening to nonphysicists, but must learn the jargon and thought processes of traders, investment bankers and credit analysts. Unfortunately, because physicists find great enjoyment in quantitative work, they may ignore the interpersonal dimension and thus define their own position in a limited manner. Although the organization may tolerate such people, they lose relevance. The result is that physicists tend to isolate themselves in situations that are not as rewarding as they would otherwise be. The physicist will truly succeed only if he or she views both the "people aspect" and the quantitative work as equally daunting and satisfying challenges. Such an equal weighting is unusual in physics and may require some reprogramming.

Success also requires innovation and creativity. It is surprising to see physicists come into the field with little experience (and hence very little prejudice on how things ought to be done) and then quickly latch on to the conventional wisdom. It's like a drowning person grabbing the first piece of driftwood that floats by. The problem with the conventional methods of finance is that they are often unsatisfactory. The field needs open and capable minds—not wet, but safe, physicists.

Career choices

All physicists today must be prepared to decide how to pursue the remainder of their careers. This choice is the common thread woven into otherwise disparate situations. "Should I go into management?" "Should I switch to the private sector?" "Should I teach?" "Should I change fields?" "Should I leave a 'safe job' to pursue my invention at my own considerable financial risk?"

In considering such questions, physicists should remember that they enjoy substantial latitude in their career choices by virtue of their backgrounds. Four decades ago, a liberal arts education was thought to prepare one well for any professional endeavor; the specific coursework may have been irrelevant, but the education process instilled intellectual discipline and sobriety. These days, a physics education serves the purpose much better, because it offers the discipline and important tools for tackling new issues. Physics is the liberal arts education for a technological society.

When I was a faculty member at an engineering school, I counseled many students at the graduate and undergraduate levels. In retrospect, I realize that the advice I gave tended to mirror my own past, and other faculty members advised their students similarly. That was natural—what we did worked well for us.

But the result of such one-sided advice is that the young physicist experiences strong forces of conformity. All of the authority figures are saying, in essence, Be like me. Likewise, scholarships and grants favor those who conform. To make optimal career choices, however, physicists must consider both conforming and nonconforming options. And because the physics establishment will not help with the nonconforming options, individuals must recognize and resist the forces of conformity in charting their careers.

When I was contemplating leaving academia, I realized that my true goals were to continue learning and to discover new challenges. These days, the challenge is, How well can I do in finance? I have yet to answer that question. When I do, I'll change fields again. For me, the realization that it is both possible and permissible to jump from one profession to another was enormously liberating. It is unfortunate that so many of us assume we cannot do it.

Recall that as a young man, Albert Einstein labored in a patent office. In that era, very few physicists were actually paid to do physics. And so in his spare time, Einstein studied Brownian motion and discovered special relativity. If he were young today, Einstein might be working on Wall Street. Unfortunately, he'd be so well compensated and so tired at the end of the day, he would never have gained such fame!

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