What are you really here for, anyway?

A primer on how to be an undergraduate student
in physical science or engineering

by

Dr. Charles A. Doswell III

Preface

This book is an outgrowth of several years of experience in talking with students. It is based in large measure on my own experiences as a student. I had to learn how to become a successful student without much guidance, but for reasons which I still don't understand, I made a large number of basically correct decisions about the process. I became a successful student and that success has led to what I consider to be a very satisfying and rewarding career in meteorology. As I have looked back, my decisions as a student were crucial in that career.

When I began to advise students, I found that most of their difficulties arose from what are basically correctable misconceptions about what college is all about. I have regaled most of my students with the contents of this book over the years and I believe that it has helped a number of them. Perhaps it will help you.

I'd like to thank Jeanne Schneider and her daughter for some very helpful comments on an earlier version of the text. And I want to thank all the students who have suffered through various impromptu "seminars" on the topics contained herein.

I. Introduction

So you're off to college and want to major in physical science or engineering! Congratulations on choosing what can be a really rewarding career. I'd guess you're one of those people who's insatiably curious about how things work. Speaking for myself and many of my colleagues, we tend to be folks who took things apart as kids, and probably got in trouble more than once because the pieces couldn't be reassembled easily. We ask a lot of questions that start out with "Why ... ?" and are not satisfied with "Because that's the way things are!" We have a huge capacity for amazement, being intrigued with things that seem to leave a lot of our friends bored to tears. A lot of us have been accused of being "nerds" or "dweebs" or whatever is the current pejorative term. Maybe that's already happened to you.

If you're on the verge of college, chances are you've done reasonably well with your high school grades and some of you may have been outstanding there. However, some of you (myself included) really didn't respond well to high school academics and have managed only moderately good grades. There are some of you who have been rebellious and troublemakers in high school, unwilling to submit to school authority figures. Nevertheless, you wouldn't be on the verge of college if your grades were *really* bad. Many of you probably found high school to be boring and succeeded only in classes where the teacher managed to reach you, somehow; perhaps you were lucky enough to have several such teachers. You probably enjoyed science and math classes, of course. Maybe only a select few of you found your favorite teachers in your favorite subjects (in my high school days, it turned out that all my best teachers were in non-science classes).

Perhaps you've already thought through your intentions on a career in science and engineering. Perhaps not. This is a good time to do it, so I'm going to try to help you do that thinking. In fact, many of the things I'm going to do in this book are intended to force you to consider your intentions and what they mean about in terms of what you should be *doing* for the next four years or so.

If you're entering college right out of high school, your undergraduate college days offer a chance to take the first important steps in becoming a physical scientist or engineer. Depending on your career goals, there may or may not be graduate school in your future. There will be time to consider that, but for now you have to begin the transition from high school to college. Dormitory life is interesting and challenging, and offers you a nice way to learn how to deal with taking care of your personal life without making you learn everything at once. Dorm meals may not suit your sophisticated palate, but cooking for

yourself drains a lot of time and energy at a time when that time and energy need to be spent wisely. You'll be able to survive dorm meals.

If you choose to strike out on your own in an apartment, be prepared for a lot of extra hassles. It might, in some sense, be cheaper to live in an apartment (especially if you share the costs with one or more partners), but I don't recommend this unless it is absolutely necessary. Having an apartment (or whatever) after the freshman year is more plausible than starting out this way.

Having a roommate will almost certainly be stressful, even if you were best pals in high school. If you room with your friend from high school, I hope you'll still be friends at the end of the first semester; many friendships can't survive the challenges of sharing the same room. If you have a total stranger for a roommate, this will be a fascinating new experience no matter how it turns out. You'll be making lots of new friends, fortunately.

If you've been out of school for a while, you may be married, perhaps even with children. Going back to school to seek out a career in science or engineering takes some courage, I think. I admit it's difficult for me to imagine it, since I didn't do it that way. If this is your situation, you *do* have a pretty big advantage over the students coming right out of high school: you probably have a pretty clear picture of what *you're* here for. Even if you've been out of school for years, going back means this is really your decision and not for someone else. You may be a bit rusty in your school skills, but those will come back quickly, so take heart if the first semester seems a bit scary. And don't let the kids give you any grief about being "old"! What you're doing is really something to be excited about and age doesn't affect your ability to feel excited.

In any case, I'm *not* going to recommend a "nose to the grindstone" approach to your undergraduate education. Quite the contrary! I hope you have a number of extracurricular things you like to do. If you don't really want to do something extracurricular, I still will bet that you won't (and shouldn't) spend all of your time hitting the books. There is all that newfound freedom for most of you, and I'm sure you'll use it for *something*. Drinking and drugs come readily to hand in college. I won't waste your time preaching, but I will say that drinking to excess and drugs are not likely to take you where you want to be. If you can't handle the freedom without falling victim to these distractions, you are putting your *whole life* at risk, no kidding. Think about it. If you think you can handle it, just remember that virtually every drug-devastated person thought the same thing. If you don't believe me, just ask the ones that survived.

For the more mature students going back to school after being away, you probably already know the value of having some time to unwind. If you have children to worry about, don't try to take your academics in big bites; leave yourself some space. Between your schooling and dealing with children, you could easily work yourself into a frazzle.

II. Issues

A. What are you really here for, anyway?

As the title of this book asks, perhaps the most important thing you need to know as you start your college career is what you're doing here. Yes, I know you've said you want a career in physical science or engineering. But why are you *really* here? If you're doing this college thing for any reason other than because it's really what *you* want to do, then you're not going to do well. Not because it's so difficult that only "nose to the grindstone" types will succeed. Not because only really smart people can pull it off. The reason you won't succeed if it's not what you want is simple: freedom. Given the freedom of college, you will be able to goof off, oversleep, skip class, etc. and no one is going to be there to hassle you about it. If you don't really want this, then you simply won't do it. You will find a way to fail.

Some of you may be going to college because it's the expected thing to do. You're doing it because someone important in your life expects you to go. But that important someone, be it a parent, a high school teacher, a friend, or a relative, isn't going to do your assignments, isn't going to attend your classes, won't be taking your exams. If this isn't something *you* want, then you'd better think this over. Wait a year and get a job. Take an extended vacation if you can afford it. *Don't go to school for anyone but yourself!*

The primary reason people flunk out of school is *not* the difficulty of college. It's in part because college is relatively easy! If you attend class, do the assignments, turn in your work on time, and generally play along, you almost certainly will not flunk out. Everyone I knew who flunked out actually had to *work* at it: marathon card games, huge drinking bouts, skipping class continually, etc. You may not make the Dean's List every semester, but if you do what the professors ask, you should be able to finish an undergraduate education. Generally, even mediocre people should be able to graduate if they simply cooperate with the program. Because it's fairly easy to be mediocre, an unmotivated person will simply let things go until it's too late to recover.

If you're interested in physical science or engineering as a career, you probably have a huge

advantage over most of your peers in college. You already have some sense of what you want to do with your life. Most of the students you'll meet haven't got a ghost of an idea why they're in school and can't imagine even what they're going to major in for the next four years, much less what they're going to accomplish with their lives. This simple factor alone can make a big difference for you.

A major issue you need to confront, though, is whether or not a career in physical science or engineering is *truly* what you want to do. How do you know that? Answering that question can only be done on a contingent basis: as you start college, you almost certainly don't know very much about what it means to be a scientist or engineer. Unless you grew up in a family where a family member was a scientist or engineer, you couldn't possibly have much real appreciation for what you might be doing. Even if someone in your family *was* a scientist or engineer, the family doesn't usually see very much about what goes on at the job. This means that *you need to seek as much information as possible about your intended career* over the next four years. The faculty may or may not be able to help you here. Unless you're aiming to join a university as a faculty member yourself someday, their perspective on your career field might be misleading. Of course, not all faculty have spent all of their adult lives in an academic environment; many have already had careers outside of the university and may have valuable insights about the career field. Look to the faculty first, but also try to get in touch with folks outside the university that are actually doing what you want to do. I'll have more on this later, but there are ways to work in your field even while you're going to school. Take advantage of these to see if this career you're aiming at is something you can envision yourself enjoying ten years down the road.

If it turns out that you don't like the courses you're taking, or if you learn more about what it means to be what you think you want to be but it doesn't really appeal to you, then you should be prepared to change majors and seek a different career. Perhaps dropping out for a while might not even be a bad choice, if you reach such a crossroads and can't make a clear decision.

By no means should you continue down this college path if you're not pretty certain it's what you want to do. Do you really want to invest four years in something that you may not want to do? The answer to that question seems obvious enough, but people do it all the time. You can't let *yourself* down by changing majors or dropping out to figure out what you really want to do. It's *your* life, *your* career, *your* decision. Don't let anyone else make the decision for you, even if it's someone you love and respect. You're about to become an adult (if you're not one already), so it's time you started to take responsibility for

your life.

B. Grades

Through high school, grades always have assumed a special place in your life. Perhaps your parents and certainly the teachers have made some of your participation in extracurricular activities contingent on your grades. No doubt your grades have had some influence on what schools you could apply to, and decided for which scholarships you were eligible. Many people in your life have been saying that your grades are important to you in many ways.

Also, grades have been the way your teachers have rewarded (or punished) your behavior in class and in school. It should be obvious to you that many of the authority figures in your life consider grades to be pretty important. Yet, many of the same people seem to be fond of saying "Oh, don't worry about your grades. They really aren't all that important." This apparent disconnect between what people *say* and what they *do* about grades is confusing and certainly is hypocritical. So what about grades?

Well, it is clear that grades *are* important! Your grades will play an important role in deciding what options are open (or closed) to you in the next several years. They may decide whether or not you get that scholarship, get into that course you want, get to participate in that extracurricular activity. I'm not about to lie to you; *grades matter*.

Grades also are an important measuring stick that can be for *your* benefit. I know that not all professors and teaching assistants decide grades in ways that seem fair to you. I know that some of you have a psychological block about tests and just don't seem to do well on exams, even when you think you know the material. There is a lot of subjectivity and arbitrariness about grades. Nevertheless, grades are the mechanism by which your teachers try to let you know how you're doing in a course. Grades are supposed to let you know how well you've mastered the material you signed up to learn. When you do poorly, they are supposed to let you know you've got to work harder.

I'll not spend a lot of time preaching about the stupidity of cheating, but if you cheat to get a grade, I'll simply ask "*Who* is being cheated? You or the teacher?" I think the answer should be obvious. If you are going to school for yourself, then the only person you cheat is yourself. If you're getting bad grades, then the message is clear. If you're not willing to address the problem (without cheating), then you should not be in college.

Many of you are have become accustomed to knowing what is going to be covered on an exam. Many of you will be asking the professors and teaching assistants to be very precise about stating what is and what is not going to be expected of you on every exam. In other words, you are asking to know what is the *minimum* you need to know in order to get a certain grade on the exam. Just how far do you think you are going to get in a career where you are only willing to study the minimum necessary? Would you like to be operated upon by a doctor who did just the minimum to get through medical school? Would you want to ride in a plane where the pilot passed his or her flight exam with a bare minimum score? What if the aeronautical engineers who built the plane all had C- averages in engineering? If that's going to be *your* approach to learning in a career of your choice, then you can only expect to be a mediocre student, no matter what grade point you have when you end your college career. And mediocrity hardly seems like a very worthwhile goal in a career of your own choice! Mediocrity in science and engineering is reserved for deadwood (frequently relegated to menial tasks) and prospective managers (who get kicked off the bench and into management just to get rid of them). I hope that isn't what you intend to be. If it is, you wasted your money on this book; see if you can get a refund!

Generally speaking, if you sign up for a course, it's either part of a mandatory curriculum or it's an option you have chosen. In either case, the strategy I recommend is that you learn *everything* available to you in that course, not what you think is the minimum to get some grade. If you approach each course as an important component in preparation for your career, *which it is*, then you should have no problem with setting a goal to learn everything you can from that course. I assert that if you do this, then the issue of grades fades into the background. Successful learning of *everything* in your courses means that grades will take care of themselves. If you accomplish this learning goal, then all the things that good grades mean are available. When good grades aren't happening, then you need to take action to address the learning deficiencies that bad grades represent. I'll be talking later about what actions you might want to take.

Perhaps you're saying, "I just can't find the time to work that hard in my courses!" Time management is a critical skill and you'd best learn it quickly. It will serve you well long after you graduate. Moreover, if your life situation seems to preclude spending a lot of time learning after class hours, then you'd be best off scaling back on your course load and planning on taking extra time to finish. When it comes to courses, your goal should always be to understand everything. Then grades are automatic. Remember that *every* course is a learning opportunity and you are not well-equipped to judge in which

ones it's appropriate to just get by with the minimum. If you know enough to make such judgments, why aren't *you* up there teaching?

C. College and a career in physical science or engineering

For physical science and engineering students, college can be thought of in terms of providing a basis for training to do real jobs. The actual job skills you need in the real world usually are fairly specific and often require specialized training after you graduate, but college is supposed to provide you with a basis upon which you can build your job-specific skills. Training assumes that you have the appropriate education and job training is not the responsibility of the college or university, so don't expect it. A degree from an accredited college says to the real world that you have learned the basics necessary to be successful in the real world, but it does *not* say you know all that you need to know.

If your ambitions are of a certain type (e.g., you want to go into research), then your undergraduate college degree is a certification that you know enough of the basics that you can go on to become more focused into specialized sub-fields and to study some subjects much more deeply than an undergraduate curriculum permits.

The Bachelor's degree in your major field, then, is a ticket of admission into either the working world or graduate school in that field. Your primary task over four years (or so) of college is to earn that ticket. If your *only* goal is to obtain that ticket, however, then you will be missing out on a number of important opportunities.

First of all, it's my experience that many science and engineering students are quite thoroughly uninterested in courses not related to their intended careers. I'll have more to say on this later, but a typical undergraduate curriculum in physical science or engineering offers a relatively wide spectrum of courses. With the electives available, it should be possible to sample many different subjects in which one might conceivably have at least some mild interest. I want to encourage all students to use their electives to *explore*. There is always time to become a specialist, but in the meantime approach each elective as a chance to expand your horizons. I *don't* recommend using electives to become even more specialized than the regular curriculum requires. You might be surprised at how much fun this approach to learning can be, and I think that treating even non-science/engineering courses seriously will pay dividends later in your life. And don't forget that every course counts in the G.P.A.!

Second, getting your ticket to the future does not preclude actually learning something useful along the way. In my experience with science, I've found that I get useful ideas from unexpected places. By treating each learning experience seriously, you can get whatever benefits are possible. If you "blow off" a required course outside your major, you are just wasting everyone's time, yours included. You (or someone) paid for the course; as long as you have to be there, why not see what you can get out of it?

Third, it's also in my experience that most successful scientists and engineers are *not* one-dimensional specialists. The scientists I know almost always have a hobby that has nothing to do with science and engineering, like music or sports or carpentry or whatever. This is a fine way to expend an elective to one's personal advantage. Take a course in something that interests you as a hobby. Often, college-level courses in a hobby area are challenging and fun.

Physical science and engineering curricula tend to be heavy in mathematics, physics and chemistry. These are quite important to you, but some of you still may not yet see how such content relates to your chosen field. As an undergraduate, I struggled with mathematics because I didn't see how it related to my career. In consequence of that struggle, I had to catch up on a lot of the mathematics I had supposedly "taken" already, when I realized I actually *needed* that course content to do what I wanted to do. The course material hadn't caught on when I actually took the course because *I wasn't ready to receive it*. It really was a scramble there for a while. If you don't always see why a course is in the curriculum, my hope is that you will have a little faith, and assume it is there because you will need it later. Chances are that course is required for a good reason, even if *you* don't see it. Theory and abstract reasoning are an essential part of physical science and engineering and there is no good reason why you should, on your own, choose *not* to learn how to use them. In fact, I can argue that you should always seek the most challenging material you can. If theory and abstract reasoning challenge you, then take as much of it as you can fit in. The same goes if you find theory easy but are challenged by laboratories and practical applications. You increase your value to a prospective employer by filling in the gaps in your background, whatever they are.

D. Time management

I've made several comments about how important it is to react properly to your newfound freedom (and opportunity). If you are going to college for yourself, not someone else, this should be a top priority. If you follow the college curriculum outlined in your field, you are going to have a pretty substantial course

load each and every semester/quarter. A big part of your success in college is going to depend on how well you manage your time. With four or five courses on your ticket each term, juggling time is going to be difficult. Exams tend to come in bunches every few weeks and courses may require term projects of some sort or another. Large reading assignments, papers, projects, homework, studying for tests, etc. can be overwhelming, especially when coming from several different sources all at the same time. If you don't figure out how to manage all this, as well as getting laundry done, participate in extracurriculars, develop interpersonal relationships, and so on, you're simply going to have problems.

Getting enough sleep, some exercise, and eating properly often go out the window, and so hard-pressed students often are vulnerable to illness (including the student's bane: mononucleosis). Without wanting to sound like a nagging parent, I want to say that it's important to eat properly and get adequate sleep. When your parents aren't there to nag you, be careful. Try to resist the temptation to put academic responsibilities off and then have to do "all-nighters" to make up for it. You probably will not pay any attention to this admonition, but it's worth a try. You'll regret procrastination, but you'll probably do it, anyway. And you'll pay the price, but you probably need to find that out for yourself.

A smart thing to do is to get a small schedule book: keep it current and carry it with you. This avoids overscheduling and overcommitment, as well as reminding you of when things are due. Most instructors are not very tolerant of late work. As I've already said, when you cooperate with the program, you're almost guaranteed to pass, if not make the Dean's List. No matter how good you are, failing to turn in assignments, turning them in late, and missing such critical events as examinations is *not* a path to success in college. Time management is a skill you will need to develop quickly. Your health is part of it, because being sick causes you to fall behind and miss things. A doctor's excuse only goes so far, and staying healthy is something that takes time management.

Be sure to reserve at least some time each week for free time. Don't book up every hour of every day every week. You should be able to find at least an hour a day when you can just unwind and "veg out" or do something physical. This doesn't count your extracurriculars, dates, etc. You will need to schedule those as carefully as your academics. And don't forget laundry, paying phone bills, etc. You're going to be busy, right? You can handle it, even if it seems overwhelming at times. I guarantee that you can do it; it just takes some thought and a schedule book.

A big thing about time management is setting *priorities*. I'm going to sound repetitive before this

book is done, but ... if you're in school for yourself, then academics have to be basically at the top of your priority list. If you can get *academic* things done first and without much procrastination, then you should have considerable time for non-academic things. Relaxing is a lot more effective when you know you've done what needs to be done. Continually remind yourself what you're in school for and you won't let academics slip down on your priority scale.

This is as good a time as any to talk about *how* to decide what you really want. All of us talk to ourselves, out loud or otherwise. One thing we can become prone to doing is lying to ourselves. This is a bad habit, and you can tell you've been lying to yourself by comparing what you actually *do* with what you say to yourself. If you say that you're going to school for yourself to prepare for a career you love, but when you look at what you're actually doing, you've been procrastinating with your academic work, then you need to reconsider what is actually the truth about why you're in school. Maybe you're doing it to live up to someone else's expectations for you. Maybe you're not as interested in that career as you originally thought. Maybe the challenges of that theory course are more than what you're prepared to confront. Whatever the reason, a conflict between what you say to yourself and what you really do is a cause for concern. What we do is a much better gauge of our intentions than what we say, even to ourselves. Be honest with yourself. Whom else can you trust as much? If you can't trust yourself, then you've got a real problem!

While we're on the subject, don't let other people talk you into (or out of) things without some careful thought. Be especially vigilant against letting others get you down on yourself or what you're trying to accomplish. There are many people who seem to need to bolster their own egos by putting others down, or by seeking confirmation of their negative views. They'll fill your head with poison, and drag you down with them. Avoid people who seem to be complaining all the time but who never seem to be interested in *solutions* to problems.

III. On the curriculum

In case you haven't been told, a curriculum is a basically a programmed set of courses designed by the faculty in your department. It's their best guess about what you need to know to be prepared to participate in your chosen field. I say "guess" because the curricula in departments are always under review and undergo changes from time to time. A curriculum is made up mostly of required courses and a

few optional ones ("electives"). I've already mentioned that you have to take this program largely on faith; many of you will decide, sooner or later, that the curriculum you went through was not entirely satisfactory. This is really rather normal. If you think you can do better, then you are welcome to try to become a faculty member and give it your best shot. However, the chance for that comes well *after* you've finished your four years. For now, just do it and quit griping about it.

Having said that, I want to urge you to take some personal responsibility for your own program. Find out for yourself what the curriculum is and what you will need to finish your degree. Keep up to date with any *changes* in the curriculum and find out how those changes might affect you. Often, you will be "grandfathered" with respect to new curriculum requirements, which means you can finish under the old requirements unless you *want* to change to the new ones. Get the course catalogs and other relevant publications, and read them. They contain much useful information and it is in your best interest to know what's in them.

By the way, you might well have good reasons for deviating from the set curriculum. Many possibilities exist but you have to ask for and obtain permission to depart from the planned program if you want to get your degree. Talk things over with fellow students, especially those who are farther along than you. And interact with the faculty on this, also. Good ones are interested in your input, and there always are opportunities for students who clearly are on the *right* track, even if it's off the beaten path. If you do try to find solutions as well as complain about problems, there's a good chance someone will listen and be supportive.

A. Academic advisors

Undergraduates typically are assigned to an academic advisor. In theory, this person will be working with you as your college experience unfolds, helping you to make the important decisions you need to make. In practice, such a person may have scores of advisees and often is too swamped to able to make key decisions properly, relative to *your* interests. Any generalization about your academic advisor is likely to be wrong in specific instances, but I found that it was in my best interest to be knowledgeable about the detailed requirements for my degree program. Then I could make up a list of courses I would be taking each term and simply go get the advisor's signature of approval to take the courses I had selected. This makes life easy for you and the advisor, who usually can't get too deeply involved with any one

student. I am not saying that your advisor is basically worthless; what I am saying is that *you should not depend on someone else* to get your program right. This is a basic tenet of being in college, and applies to the rest of your life.

B. Selection of optional courses

There are two types of optional courses: 1) courses that must be selected from a limited set of options, and 2) wide open options. In the first case, these might include a choice of so-called "science" or "math" or "language" electives. Most students tend to select these electives on the basis of which one is *easiest*. Such a path is the one of choice for mediocrity, and is not my recommendation if you intend to be a scientist or engineer who excels at the profession. In fact, the decision about which elective to choose should be guided by what I consider to be the most basic decision-making tool of your collegiate career: *choose that elective which is the one most likely to take you where you want to go*. If it is your intention to be an engineer or scientist, then taking a challenging math elective might well be the right one. This is no simple generalization about making choices, even though it is easy to state. I can illustrate it with an example from my own college days. I elected to take two semesters of mathematical statistics as an undergraduate, because I knew even then that I would need statistics later. It was not required of me, but I felt convinced that it would be important. And I have never regretted making that choice, even if it was by far not the easiest among the choices I had.

For optional courses where the choices are wide open, I recommend taking courses that will be fun. I already have said that this might be a chance to take a course related to a hobby. Or if you always wondered what some subject might be about and want to learn something about it even though it has nothing to do with your chosen career, then by all means take this opportunity. Such courses can be the *spice* of your college days, while the required courses are the basic food groups. I used my options to take a geology survey course and a very challenging and interesting course in drawing. In both cases, I felt they were very worthwhile, and made their own contributions to my life.

C. On teaching assistants and professors

I can remember how disappointed I was to find out how much of the actual teaching in college was done by graduate teaching assistants (TAs) instead of professors. I had not even heard of such a thing

until it was happening to me. If you are not aware of this fact, at least in major college programs (it may not be as true in small colleges as it is in major state and private institutions), then you should know that you will be taught by graduate students a good percentage of the time. Many large lecture classes are taught by a professor, and then you break up into smaller "discussion" or "laboratory" or "application" sections supervised by TAs. You might have lectures on a Monday-Wednesday-Friday schedule, with a discussion sections on Tuesday and Thursday. The discussion section, with perhaps 10-30 students, gives you a chance to delve into questions that might be inappropriate in the context of a large lecture in front of, say, 500 students.

Most of you should know by this point in your education that there are good teachers and bad teachers. You tend to take a personal perspective on this topic, and the teacher you detest may be someone else's absolute favorite. Not everyone likes food prepared the same way, or the same movies, or the same music, so it should not be a surprise that you are going to have to make this evaluation yourself to be certain. Someone else's review of a teacher may not be an accurate reflection of what you would think of that teacher. That makes school at all levels a sort of "crapshoot" and sometimes it comes out "craps!" There is no way I know of to ensure that you are going to have an unbroken string of good teachers. If your educational outcome depends on having that unbroken string of good teachers, then you might as well quit now. It's not going to happen!

If you think your teacher stinks, what can you do? In some cases, you can drop that class and add the same class but taught by someone else, if your schedule (and theirs) permits. In some cases, you might drop that class completely, take another entirely different class, and make up the one you've dropped later when someone else teaches it. Failing all such options, you may have to grit your teeth and complete the class anyway. This is not easy but I can almost guarantee you're going to run into this situation sooner or later, so you'd better understand that the responsibility for mastering the material (see below) is always yours, not the instructors.

TAs are not necessarily good or bad teachers. The same is true for professors, of course. Your experience in getting through high school is full of examples of good and bad teachers, and it will continue to be true as you go through college. However, you have more chances to influence the outcome in college, because you have more choices in the matter. Often, certain courses are taught by several different professors at the same time, and you can juggle your schedule to try to get a particular professor. However,

TAs typically are not chosen until the last minute and so you have little or no choice about your TA.

To the extent that you have a choice, I want to offer a suggestion for how to choose one, in case you are not already knowledgeable about your choices. Listen to the *mediocre* students who have already taken the course! This seems strange, but what I want you to do is find out which teachers challenged the mediocre students. The losers will be saying "Don't take physics from Professor So-and-So! He works you to death!" And then you go out and sign up with Professor So-and-So! *The teachers the mediocre students fear are the ones you want*. Now some teachers are feared because they are outright nasty; some of them take delight in humiliating students, some will never give better than a "C" to non-majors, etc. The idea is that a teacher who challenges you and makes you work hard to learn is someone to seek out. The ones who make life *unnecessarily* difficult are to be avoided, of course, but be sure you understand that learning is not always easy! You will always look back at the ones who challenged you, even if it was painful at times, as your best teachers. Ask anyone who has become successful in your profession.

I should mention the problem with both professors and TAs who are not native English speakers. The odds are quite good that you will run into several of them before you're done. I found that my ability to understand foreign accents improved with time, to the point that by the end of my undergraduate days, I felt far less uncomfortable with non-native English speakers than I did at the start. Often such teachers are quite good if you can get past your discomfort with trying to understand them. I believe that most such problems can be overcome with some effort, some patience, and by paying close attention. If you miss something in class, don't be afraid to ask for clarification!

If you are taking a course as part of your college curriculum, then presumably you need to *know* the material contained in the course. Whose responsibility is it to ensure that you learn the material? If you think it is the professor and/or the TA, then you may as well quit now. Given that teaching quality is something of a matter of chance, then you must understand that it is *your* responsibility to learn the material. Teaching is not a matter of reaching out, pulling the tops off your heads, and pouring in a load of knowledge. Learning is not a passive activity, where you sit back and expect the teacher to do all the work. The process is a two-sided one, and if it seems to breaking down, then you need to do something about it besides complain. I'll have more to say on this later.

D. Communication skills

If you are majoring is science or engineering, then you almost certainly have a problem. You may regard subjects like English grammar and composition, or speech as a waste of your precious time. I think I can understand how you feel, and I want to try to convince you of the error of your ways. In fact, I want to assure you that prospective employers are going to be *very* interested in your communication skills! Why? Well, to a great extent, science and engineering accomplishments depend on your ability to communicate them. Scientists spend a large portion of their careers writing and presenting scientific papers. Their ability to communicate their ideas is a critical element in their success. Engineers likewise need to communicate what they are doing to their peers and their management, to convince them they have the right design. Therefore, you need to be developing your communication skills. End of discussion. You've been told. If you don't believe me ... you could simply ignore this advice. Time will tell whether or not this was the right decision, and if you neglect developing those skills, only to discover later how important they really are ... well, I'm not going to feel sorry for you.

In my case, my best teachers in high school were in English! That turned out to be a lucky break (It didn't seem that way at the time!), because they made developing communication skills fun and interesting. I was astonished later to find that many of my peers couldn't put together a coherent English sentence on paper, and didn't have a clue about how to organize and make an oral presentation. Do not depend on luck for this important aspect of your professional career! If you didn't have Speech in high school, check with the university counseling office. There may be some courses available, or they might have something like "Toastmaster's" (a program designed to overcome people's fear and discomfort with public speaking).

IV. Class time

You are going to spend a fair amount of time in classrooms during your college days. Classes dominate your scheduling, organizing and structuring the days of a successful student. You need to make good use of your time in class, because it's when you make the majority of your contact with the folks who are trying to give you what you need to be a success in your career.

A. Taking notes and listening

If there is one important principle to class time it is that you should spend the majority of class time *listening* to what is being presented. All too many students are wasting their time trying to transcribe the

lectures; if you want a transcription, hire a stenographer or bring a tape recorder! Your task, in physical science and engineering lectures, is to *understand* what is being said. If you don't understand what is being said, your notes usually aren't going to help you. All too many students refuse to ask questions (see the next section) but defer their questions to time after class. This is really dumb. Beautiful comprehensive notes are a waste of your class time (see the homework section), so what limited notes you take should be confined to the bare minimum, the key points in the presentation. And don't worry if the notes are scribbled and sketchy.

A common refrain among students, especially those in science and engineering programs is that the lecturer goes too fast, and their only hope is to transcribe the lecture, including the equations, and then sort it out later. I believe this can be the case at some times, and there are some teachers (professors or TAs) who simply refuse to be slowed down. Obviously, those are poor teachers, since the goal of true teaching is understanding, not getting through the syllabus (I call it the "silly bus"). You will run into them, so how to deal with it? There are several possibilities. (1) If the details are in the book, then you can simply follow along in the book and you won't have to take notes at all. (2) The teacher has a set of prepared notes. (3) The content isn't documented anywhere. Clearly, it is case (3) that causes a problem. I still assert that taking those detailed notes isn't going to be much good, but you do need to have a *functional minimum* of notes, so that you can reproduce the chain of reasoning when you get out of class (see discussion below on non-class time). And you had better do that right away, while it's still fresh in your mind. Then any questions that remain must be dealt with during office hours, by meeting with the lecturer before or after class, or even by working it out with your classmates. If you do the latter, be careful! You might want to check with the lecturer and make sure your understanding is correct.

Why are you taking notes? What's the point? If the object is to understand what is being said, I contend that your time is better spent listening than note-taking. If there is any other objective, I can't imagine what it would be, unless you are planning on publishing the lectures later (which probably would be illegal or at least unethical!). If you combine your work outside of class, that resolves questions and confirms your understanding of the recent past lectures, with careful attention during the class presentations, then you automatically become a better listener.

In science and engineering classes, each topic builds on the previous one to erect a structure. Failing to understand something cripples your ability to understand the next topic, and everything that

follows. Failing to understand something creates a pit that becomes deeper and deeper with each passing lecture, until it can get so deep that you can't climb out of it. Conversely, understanding each topic prepares you to understand the next. Therefore, to the maximum extent possible you need to understand everything that is said, *as it is being said*. What you understand, you can reproduce when it is needed (on exams, but more importantly, on the job after you graduate). What you don't understand can only be memorized and regurgitated, a poor substitute for learning. Memorization might get you graduated, but it won't do a thing for you on the job. Understanding stays with you and is the key to a successful career in science and engineering.

B. Class participation

If understanding is the key to your class time, this means that you necessarily must ask questions during class. There might be no opportunity to do so in a huge lecture (although that is a bad lecture format, in my opinion), but if you get snowed by something the lecturer says, it's your responsibility to get the issue figured out as soon as possible, preferably during class. The rest of the lecture might depend on the point you are not getting, so by failing to get it straightened out, you will have wasted the rest of the time spent in the lecture.

All of you have heard that there is no such thing as a stupid question. Well, I disagree. There *are* stupid questions, and you're probably going to have to ask a lot of them before you're done, if you do things right. Even though you might be asking a stupid question, it's a serious mistake to let it go unanswered! If your lecturer refuses to let you ask questions, go complain to someone over his/her head, because that's grossly inappropriate behavior for a teacher. If you ask your question, stupid or otherwise, then a number of good things can happen: 1) you slow down the pace of the class and give everyone a chance to think through what's being said, 2) you let the lecturer know that the material is not sinking in, 3) you let the lecturer know that at least someone is listening and cares enough to ask questions, 4) if the lecturer has made a mistake, then he/she and everyone in the class gets it cleared up. The absolute worst thing that can happen is that you will be laughed at by everyone else in class because they already know the answer. This seems to be the most fearful thing imaginable, and I can't imagine why! First of all, it almost *never* happens, because you almost always are not the only one wondering about your question. Second, even if it *does* happen, at least you got your question answered. Who cares what the rest of the class

thinks? Are *they* going to be living your life, doing your work for you, and supporting you? You need to learn to ignore what other students think about you and your questions.

If the lecturer uses a style that asks a lot of questions of you students, then if you have any vague idea about how to answer the lecturer's question, go ahead and volunteer. Sure, you might sound stupid at times. It may come as a surprise (although it shouldn't) to you, but virtually everyone says stupid things from time to time. The only people who don't are those that don't say *anything*, and that's *really* stupid. If the lecturer asks questions, it's to get feedback, to make the learning process a participatory exercise, not one of passively soaking up the jewels of knowledge being dispensed. This is a good lecturing style (I try to use it!), and indicates that the lecturer is interested in what you have to say. So go ahead and say something! And don't whisper it, as if you were afraid of being wrong; speak right up.

You should try to sit in the front row, if possible. Those who "hide" in the back rows are really not all that inconspicuous, and being in front means you can interact easily with the lecturer/instructor. Only losers hide in the back row, and lecturers know that anyway, so it's a poor strategy even if all you're trying to do is hide. Hiding actually is easier on the front row but that's not why you should be there, if you want a career. Get your hand in the air at every sticking point, so you can get it answered. If students show that much interest in the material, good lecturers are usually pleased, not upset with all the questions. Take as many classes as possible from such folks. Any lecturer who isn't pleased is probably a loser and you're going to have to work all that much harder to master the course content. Don't enroll in his/her classes ever again, if you can avoid it. You can't prevent having bad lecturers/teachers, but you can minimize their negative impact on your education by assuming the responsibility for "getting it."

C. Homework

Ever since you started going to school, you've probably disliked homework assignments. Ask yourself these questions. Why are you assigned homework? Do you suppose the grading of homework is fun? What's the point?

Well, the objectives of homework are many and varied. Exercises in various techniques teach familiarity with new methods and illustrate the value of the techniques. Doing proofs and derivations develops familiarity with mathematical methods and shows the origins of mathematical statements. Problem-solving is a skill you are going to need in your scientific and engineering careers, so you should

welcome the opportunities to solve problems. Word problems (I *know* they're your favorite!) are the best for developing useful job-related skills, so the more of them you are assigned, the better for you. Moreover, if you can do the homework assignments, you confirm the understanding you have developed (hopefully) by listening during the lectures. Having the technical concepts you've learned in class confirmed by doing something with them (like problem-solving using that theory) is the next step to true understanding of those concepts. By the way, doing lots of homework and having that homework count toward your grade decreases the impact on your grade of choking on a test (see the next section). This can give you the confidence you need to do well on tests. Best of all, homework is your chance to slow down and think about the material.

Some of you might have had chances to do homework assignments while still in class during high school. This is almost certainly not going to happen in college, so don't expect it. The instructor may choose to go over homework assignments in class. If you have done the homework, then you should be willing to volunteer to present your solutions; don't wait to be called upon. This gives you direct feedback from the living, breathing instructor instead of his/her scribbled comments on your papers; you have the chance to get immediate clarifications if you don't follow the response to your presentation.

D. Examinations

Let me talk a bit about examinations in general before I go on to talk about the in-class part of exams in particular. As with homework, you might want to mull over some questions about examinations. Why do teachers give exams? Do you suppose that grading exams is fun? What's the point?

Exams, plain and simple, are a mechanism for both the instructor and the students to measure how well the course content (concepts and skills) is getting across. Exams are important to both sides for this reason and this reason, only! I believe that each exam is your chance as a student to find out how well you're doing, and to develop a course of action if necessitated by a poor performance.

I doubt if anyone is more empathetic than I about how some students just can't seem to perform well on exams. I've been there. The test can become a psychological barrier; a fear-generating exercise that dooms the performance before it even begins. If I can overcome this fear, so can you. The whole secret to doing well on exams is *confidence*. Confidence is based on performance and vice-versa. Poor performance can lead to a downward spiral of fear and frustration. Good performance leads to better

performance in an *upward* spiral of excitement and confidence. Avoid programming yourself to further poor exams by telling yourself negative things if you happen to do badly on any particular one. Don't tell yourself with every bad test that "I just can't seem to do well on tests!" or "I'm just not getting this stuff!" or "I'm going to flunk out!" All you're doing is reinforcing a self-defeating attitude.

What began to happen with me to help me out of that was that I was pretty sure I was *understanding* the course material, based on lower-pressure measures, like homework. If I understood the material, the challenge became how to overcome the fear of doing badly on exams. I had to convince myself that (to quote Franklin Delano Roosevelt) the only thing I had to fear was fear itself. I began to get *angry* with myself and anger was a better response than more fear. I started telling myself "I *know* that I've learned this material, so there's no reason for me to do badly!" I also quit cramming before tests (see below). Once I got a few good performances behind me, the fear disappeared and the good test performance never went away. That's not to say that I never did relatively poorly on any test thereafter, but I always knew what I had to do to respond to a relatively poor performance: work that much harder to assure myself that I really knew the material. If I did relatively poorly on an exam, it was not because I choked; rather, it was due to a poor understanding, and I could do something about *that*.

I'm not going to waste much time about cheating on exams. I've already noted that cheating of any sort is simply short-changing yourself. If you care about a career, then cheating is a bad habit to develop, because you really do need to know what you're supposed to know; if you cheated, your employer may find out that you don't actually know very much. Your career will not be a long and pleasant one if your employer knows you don't know very much.

Now for what will probably be a controversial and startling statement: *studying for your exams is cheating*! What do I mean by that? What "studying" I am referring to specifically is the last-minute cramming that many of you do before tests. I do *not* mean the daily effort spent in working to understand the course material. A steady, non-stop effort on a daily basis is vastly more effective than a crash effort to cram the entire semester into your head in one night. What gets put in your short-term memory is quickly gone. I found that this exercise typically led to *confusion*, not understanding. Even if you manage somehow to do well on the test in this way, you have misused the opportunity that the exam represents: the chance to gauge your true level of understanding. The high test score is a false reading, and you have convinced yourself falsely that you're doing O.K. Who is being cheated? You are. And it will show up

later in many embarrassing and potentially career-destroying ways.

A better thing to do than cramming the night before an important exam is to relax. Spend the evening doing something to get your mind off the pressures of the test. Go to a movie, attend or participate in a sporting event, play video games, get in a bull session, whatever. A really stupid thing to do before a test is to go to a party and get high. Get back early from your relaxation and get a good night's sleep, unlike your foolish friends spending an "overnighter" cramming! I can almost guarantee a better performance on the test than theirs. And the performance will be a truer test of your knowledge. I challenge you to quit "studying" for tests in this way!

V. Non-class time

You certainly will spend a lot of time in class, but you will spend a lot more time *not* in class. How you use that time is going to be another important factor in what you get from your college education.

A. Homework

The obvious advice about homework is simple: *get it done* before anything else you do. If that means you don't do much else -- well, what are you in college for, anyway? You've probably been hearing this advice from your parents, teachers, and half the known universe ever since you started school. Are you ready to start thinking there might be something to that advice, after all? If not -- well, I doubt that anything I can say to you is going to change your mind. The choice is yours.

There's a special kind of homework that most of you won't do, but which I recommend highly. Do the problems that the instructor *didn't* assign. If the book says "The proof is left to the reader." then do it! If some odd question that may not be covered in the book (or the lectures) occurs to you, then see if you can work out an answer on your own. If the lecturer said that you would *not* be responsible for a chapter in the book, then work through it, anyway. Show your work and discuss the material with your lecturer or TA to see if it's correct. Basically, all this extra effort should be done after you finish that part of the homework that is required of you, so it's going to cut into your spare time. But it's time well-spent if you want to excel at your chosen profession.

B. Studying effectively

I'm going to suggest a plan that you might want to try if things don't seem to be working out as well as you think they should. Remember I said that your class notes should be really sketchy, with only the high points written down? Well, a really good way to test that understanding of the lecture you thought you had while you were listening is to take your sketchy notes and try to write down a complete presentation of the arguments. In effect, you are "re-copying" your notes, but *not* like a mindless stenographer. The idea is to see if you can take your limited notes and *reproduce in detail* the concepts you just heard that day during class. It reinforces the understanding you have developed and if there are any gaps or flaws in that understanding, it points them out pretty quickly.

The next class, or during the instructor's office hours (remember to *use* those opportunities to interact with your instructors), get any gaps or flaws in your understanding worked out right away. Those questions represent weaknesses in your foundation of knowledge, so the quicker you get them answered, the more prepared you are to build on that foundation. Doing this also builds confidence in your understanding of the class material, an important part of the confidence you need to do well in all aspects of your education.

As a bonus, you will end up with a really neat, well-organized set of notes. Of course, if you don't keep up with this program, it is obvious that you can fall very far behind in a short time and, in doing so, you will almost certainly give it up. You really need to keep up with every day's lectures and get the notes "recopied" *that night*, while the material is still fresh in your mind. And, of course, this adds a considerable amount of daily homework to what is being assigned. However, this might well make the homework a lot easier to finish. You probably will not have a lot of spare time, though.

I began this course of study sometime late in my undergraduate days and I found it very effective for myself. It might be the answer for some of you, or it might not. I offer it as a technique, but there may well be other techniques better suited for you, personally.

No matter how you do it, *effective* studying means that you have mastered the course material. You should be satisfied with nothing less, in any course you take, including the non-science or non-engineering courses. I can't offer as structured a plan of study for humanities and other non-technical courses; that's not the intent of this book. But you should seek to gain whatever learning you can from every opportunity, and every course asks that you seek understanding, to learn the material, to master its application. In addition to the homework, you should attempt any extra credit assignments, do proofs and derivations that

are "left to the reader" in the book or to the "interested student" during the lectures. When the course material suggests questions that are outside the range of the course content proper, go ahead and see what you can do. Ask your instructor to evaluate how well you did in these extra things, even if there is no formal extra credit (although that may be an option). The difference between mediocrity and excellence is not a huge gap; it's just that the mediocre student is satisfied with doing the minimum and the outstanding student is *never* satisfied with the minimum. If you go there, the "extra mile" is not very thickly populated, ever.

Of course, you need to be prepared to encounter some teachers who are not willing to help make sure that you've done these extra efforts correctly. The "extra mile" in teaching is also not very heavily traveled! If you run into a professor or TA who is unwilling to help you, see if you can find a faculty member or graduate student that is willing to help out. If worst comes to worst, you may not get much feedback at all. Nevertheless, you should carry on with these extra efforts. Never let a bad teacher stand between you and your career goals.

A final thought on effective studying: there are times when pounding away hour after hour on a science or math or engineering problem is just self-defeating. There are going to be homework assignments, or new concepts in class, or whatever that you're simply not going to be able to work through to the finish. I can't give you a simple formula for how to recognize the point where you need to put things down and work on something else, but you're going to *have* to learn how to recognize that point! Any further effort beyond that point is a waste, so learn to put that work away and do something else. *Anything* else. If time permits, you may have to sleep on it. This is a tough thing to teach yourself, because it sounds like procrastinating.

Often it helps to talk about your dilemma with some classmates. In a lot of technical problems, just describing it to a classmate will be enough; the solution will become clear when you have had to explain the situation to someone else. The typical things that cause you to get stuck in science, math, and engineering problems are: 1) making the same mistake over and over and not realizing it, 2) forgetting some basic principle that allows you to fill in the gap you've encountered, or 3) not seeing (or knowing) some trick that enables the solution to drop right out. In many cases, talking it over with a classmate will get you past these common stumbling blocks, because they will have a fresh viewpoint and might see right away where your problem is. Or you might recognize it as you talk about it with them. This clearly means

that learning how to interact positively with your classmates is a good idea.

C. Extracurricular activities

Although it sounds like I am advocating a monastic existence for your years in college, I really do not think that is a good thing to do. If your course load leaves you absolutely no free time, then I recommend you think seriously about dropping one course and pursuing some non-academic, extracurricular thing. Finishing in a particular time is not a necessity; it's a goal, but it needn't be an obsession. It is important to your academic excellence that you have something to do that is not schoolwork. Participation in band, or working on the school newspaper, or some sport (even the college's teams, if that is your goal and you have the ability) is a good way to shed the pressure and stress of classwork for a few hours. You *need* to get away once in awhile, even if it's only for a few hours. If you have a hobby that you really enjoy, like painting, or amateur astronomy, or bird-watching, be sure to continue it through college. You don't have to live as if you were in a cloister to be a successful student. All it requires is time-budgeting.

D. Friends, roommates, and the opposite sex

For many of you, this will be your first time of extended absence from home, family, and the friends you had before college. In compensation for that, you will be developing a whole new circle of friends. Many of you will be sharing a room with someone not related to you for the first time, and there is the opposite sex around you in abundance (unless you're at a unisex school, of course). This can be exciting, frightening, happy, and sad; perhaps all at the same time.

I'm not in a position to tell you how to deal with all of this; you're going to have to work that out for yourself, mostly. But I can say that having such a drastic change in your situation can be tremendously stimulating. You may find yourself doing things you've never done before. Like cleaning up your own room, for instance. Suddenly, when your parents aren't around to gripe at you about your slovenly habits, you find you don't need to show your independence by being sloppy anymore. The same goes for your study habits; without the pressure from your parents, there is no need to goof off and you find yourself developing work habits you never imagined yourself having. This is a normal, if not typical response, to your new freedom. If your habits don't change very much, this doesn't mean you're weird.

The point of saying all this is that I want to encourage you to sample the new experiences you are going to have. I definitely do not want you tied to your desk, working like a slave day in and day out. There's time aplenty for concentration ... like when you get to graduate school, or at your job after graduation. You can be focused on your goals without being *consumed* by them. Your first (and perhaps your last) four years of college ought to be a time of exploration, of looking at the wider world around you and experiencing as much of it as you can handle. Go ahead and have those late-night bull sessions in the dorms, do as much dating as you feel you want to do (without sacrificing your academics, of course), and enjoy the experience of a roommate. A roommate is not all that dissimilar from a spouse, and learning to deal with the idiosyncrasies of a roommate is good experience, even if you decide to part company after awhile.

If you happen to be coming back to school after being out for awhile, then the newness of living away from your parents is probably gone, especially if you are married and have children. Since I didn't have that sort of experience, I probably can't offer much, except to say that school can put a lot of stress on family relationships. Going to school demands much of a student's time and a student's spouse (and/or children) may feel neglected and pushed away, or even used. A spouse may be working to support the whole family while you go to school. Financial problems are a fact of life while going to school, and the effect of such problems on relationships is well-known. This is part of the challenge to mature students, returning to school with a spouse and perhaps children. On the other side of that ledger, a family can be a source of support. It helps to have someone who believes in you and perhaps even admires you for your efforts to become what you are trying to be. Further, by forcing you to spend time with them, your family can be a much-needed diversion from academics. By having already experienced a lot of life on your own, you can simply go about the business of your life, without having to cope with the fears and challenges of new-found independence.

E. Summertime

If I were a nose-to-the-grindstone sort, I might be recommending that you spend your summers taking classes, but by now you should expect that that's not what I'm going to recommend, in general. There might be a time when going to summer classes might be useful; for example, to take a required course so that you have room in your schedule for an elective course that's only offered in the fall.

Generally, however, I suggest that you use your summers to go have fun somewhere or to explore, via a summer job, what your projected career might be like. If you want to be a scientist or an engineer, it's a good idea to use the summer to find a career-related job. Find out what real scientists or engineers do by working with them in some way, even if it means you make little or no money. There are lots of opportunities for you to work with scientists and engineers during the summer; ask your faculty, your advisor, and other college sources (see below). The only reason to seek money instead of career-related jobs is if you are desperately in need of income to keep you in school.

Finding summer jobs in your field may or may not be difficult. Faculty members are probably the first place you should look. The university might have some opportunities in a laboratory or institute, or in a work-study program where the "work" part is focused on the summer. Since it always helps to make contacts with working professionals outside the university, you should be making such contacts whenever possible. They might have summer programs available or know of places where such might be available. Nowadays, summer programs often are advertised on bulletin boards (both physically and in cyberspace) and flyers are sent to appropriate university departments.

Not only are summer jobs useful to you in helping make career decisions, but they give you something non-academic to put on your résumé. Prospective employers like to have someone besides faculty members to ask about your qualifications for a job. It's nice when they can find out how you behaved in a real job in your field, and it's a big plus for you, compared to those of your peers who have stayed in school 12 months a year for four years.

Just going somewhere and having *fun* is not altogether bad, either. You might well come back at the end of the summer re-charged and ready to get back on track. And if a summer's play convinces you that going back to class is *not* something you look forward to, well ... maybe you need to reevaluate how important school and your chosen career really are to you. A summer away from the books should not be enough to change your commitment if it really *was* a commitment.

For mature students with families, it might well be quite appropriate to take summer courses, in order to finish the whole educations process as quickly as possible. If financial considerations enter, of course, a summer job might also be a major relief to the financial pressure associated with school. Moreover, many of the same considerations discussed above apply to mature students just as much as for those going directly into college out of high school. A summer away from the books can also be useful to

mature students, in order to re-establish close relationships with the rest of the family. No matter what the situation is, it is useful to consider getting away from school during the summer, but students should make that decision based on their particular situations.

VI. Resources

A. College programs and counselors

The average college offers many programs to try to help you be a better student than you are at any given moment. Because you represent a source of income to them, the university really wants you to stay with the program and there are many folks genuinely committed to helping you. But in college, you have to *ask for* this kind of help. It's not like at home where your folks were constantly badgering you with "help" even when you really didn't want it. Most such student assistance programs have far too few takers among the students. My advice is to check these things out, and if they can make you a better student, then it's probably worth the investment of some of your time.

Student assistant programs vary from school to school, but can include:

Tutoring
Crisis intervention
Psychological help
Career counseling
Technical services (computers, typing, technical drawing, etc.)
Religious counseling
Social services
Academic skills (studying, using the library, note-taking, standardized tests, etc.)

In the same way, there is a host of folks who are at least nominally charged with providing you with help, including your academic advisor. Again, you have to *ask for* the help, for the most part. This "help" may not always be truly helpful, since not everyone that volunteers (or even the ones who hold down an actual, paid job) to help you is well-qualified to be of genuine help. Check these things out, but remember that *you* should shoulder the majority of the burden for developing your own program. Counselors and advisors can be a rich source of useful information, but in the final analysis, the decisions are yours.

B. Professors and Teaching Assistants

I have indicated that the faculty and assistants are charged with teaching you. This is fine on paper,

but it is a fact of life that, at least at "big-time" universities, the science and engineering faculty are judged mostly on the resources they bring in to fund their research programs. Teaching skill can be a paper qualification, but many of the more successful researchers are lousy teachers simply because their hearts are not in it. They'd rather be in their labs, or whatever, doing the research that leads to publications that are, in turn, their key to more research grants. Good TAs can be outstanding teachers; I once had a TA who was by far the best mathematics teacher I ever had as an undergraduate. But many TAs are the second rank of graduate students, becoming TAs because no professor wanted to support them on his/her research grant.

It would be ideal if every professor and TA was really committed to teaching, but that is not generally the case. If you encounter a less-than-ideal instructor, it is going to take a real effort on your part to get the course material mastered. You have a right to expect some contribution from the instructor: most universities require instructors to have office hours, where they make themselves available to students. Take advantage of them as often as you need them. Go visit them to ask questions even if you don't like them as teachers. Ask them to tell you about their research and stand back! You might get a real earful, and possibly more. Some of the poor teachers will be really enthused about their research and you might be surprised at how excited (and exciting!) they can be when talking about their passionate involvement with science or engineering. If nothing else, you might get a lot of useful information related to career topics this way.

I've already suggested that you need to be asking a lot of questions in class. You might be told by a lecturer to defer your questions until after class. Make sure they stick to their promise to answer your questions, even if it means making an appointment with them outside of class and office hours.

It's generally a good thing when the instructor knows your name, especially if you've made yourself known by being interested enough to actually try to learn the course material. Grades tend to take care of themselves if you follow my plan of attack in college, but it can't hurt to be given the benefit of the doubt in a borderline grade situation because the instructor knows you're really trying to learn.

C. Students

Your fellow students are an underrated contributor to the quality of your education. If bright, motivated students surround you, then it enhances *your* motivation. If the overall quality of the students is

low, then you may tend to sink down to their level. On the assumption that you're committed to excelling at your chosen profession, it doesn't take long to identify the losers and the mediocre majority. You'll recognize them easily. Stay away from them, and don't let their envy of your accomplishments cause you to reduce your effort level. They're not going to support you after your graduate; they're not going to do your work for you; they're not likely to accomplish anything of substance. Why lower your standards to make them feel better about their minimalist efforts? Pick your colleagues from the folks that sit in the front row of your classes. Hang around with upperclass students when you're a freshman or sophomore. Hang around with grad students when you're a junior or senior. Work with the classmates that seem to be interested and capable, not the ones who are griping about the workload and spending most of their time partying. Pattern your academic habits around the ones who are proven successful, not the "popular" ones who are struggling to stay off academic probation.

Chances are you will recognize the *good* students in your class right away, as well. They're the ones who volunteer to answer the instructor's questions, who catch mistakes in the instructor's lectures, who get the highest homework and test scores. Find out what they do. Chances are they are not really *smarter* than you are, but they may well be *working* smarter than you. You can learn a lot from your classmates, and you might well be able to offer them something as well. In fact, such a relationship works best when it is not all one-way, so you need to contribute your share to the process of helping each other learn the material thoroughly. And don't sell yourself short by convincing yourself that you can't do what you see others doing. That kind of negative thinking will defeat you every time, in a way that no mere setback can defeat you.

D. Income

There is a fair chance you will want to earn some money while you're going through the program. Unless you're filthy rich, or on some sort of full-free-ride scholarship, your finances can get a little tight. And it's a real pain to be asking your folks for money all the time; they tend to get up on a soapbox and give you a speech every time you do. I've already mentioned summer employment as a way to gain work experience, but it doesn't hurt a bit if you can get paid doing it! As noted, unless you're really strapped for money, it is better to get paid less but to get more worthwhile experience. But that high-paying construction job might be helpful on the financial side. The choice is yours, and you don't have to make the

same choice every summer, of course. It's just that summer jobs of a particular sort are easier to get if you've worked there before (assuming that you didn't mess up in some big-time way and the employer hates your guts, or vice-versa).

Part-time jobs during the school year don't hurt, either. However, having a job during the school year means you have to worry about the conflict between work and academics. Generally speaking, if you work more than about 10 hours a week, you're going to have problems with a full course load. That much work will get you extra spending cash, but won't pay your tuition, room, or board. If you need to get major elements of your educational costs (tuition, room, food) paid for by *your* work income, you almost certainly are going to have to enroll in less than a full load, and that means the degree takes longer than the basic four years. You need to deal with the appropriate balancing act; taking on too much will burn you out well before you finish, perhaps leading to serious illness, major stress on your body and psyche, and lots of problems of all sorts. Working can actually be fun if you are working for someone in your major field, but you need to remember that, for undergraduates, classwork should take the highest possible priority. If your grades or your attitude begin to slip, cut back on the outside work and stay focused on the courses.

Married students with families have a different set of problems. Income to support the family must come from somewhere, especially when the student is paying for his or her own education (that is, not on a full scholarship). The priority list for married students, especially those with children, starts with the family, then with any work needed to support the family (including family responsibilities), and only then can academics intrude. As I've said, going to college with a family puts a lot of stress on everyone, perhaps especially the student. Burn-out becomes a real problem in such situations, so everyone in the family should understand what is going to happen as best they can and the student may have to compromise on academic goals to keep the family together. As with students fresh out of high school, it will take a considerable effort to stay focused on academics, but for different reasons.

In either case, students should understand that some scholarships require a particular level of participation. Cutting back on courses might cost you your scholarship, and that might degrade your financial situation even further. Finances can be a real struggle.

E. Special programs

Many departments offer specialized programs in physical science or engineering: double majors,

degrees with special emphasis, and so on. And virtually every department has an honors program that allows for enriched opportunities. If you qualify for special programs that sound appealing, I suggest you should go ahead and sign up for them. It might turn out that you don't care for it after you've tried it for a year; fine, go ahead and drop out of it. Doing so won't be a disgrace, but if it turns out to be something that really challenges you in a good, stimulating way, then it will have been a good gamble. If you'd like to try one of these but your grades aren't good enough to qualify, ask if you can enter the program after you get your grades up. In such a case, you have a real incentive to do well, which never hurts.

VII. Your senior year

Your senior year is a special time. You've come a long way and you may not even recognize it! You're about to graduate, and it's time to look beyond the four delightful years you're about to complete.

A. Decision time

As graduation approaches, a junior in science and engineering needs to think about an important issue: graduate school. Although it is quite possible to have satisfactory careers in either science or engineering with a Bachelor's degree, there are many doors that only open to those with graduate degrees. You need to *know* how important graduate school is going to be for your career objectives. Remember that as you have gone through an undergraduate program, your knowledge level about your chosen profession has grown by leaps and bounds. The notions you had when you entered college may have undergone a major transformation, so it is worth spending some time re-thinking the whole situation.

Of course, going to work does not preclude returning to grad school later. There may be a whole host of reasons why it might be right for you to get a real job for a while. But remember that each year after graduation in which you do not go back for that graduate degree reduces the likelihood that you will indeed go back. If your career objectives include a need for grad school degrees, you will be best off going right on to grad school (after your summer between graduation and grad school). Don't hand me that "burn-out" argument, either. If you're burned-out after a four-year Bachelor's program, then get another career. You should just now be hitting your stride.

B. The Graduate Record Exam

The Graduate Record Exam (or GRE) is another in the seemingly endless series of exams like the ACT, the SAT, etc. that you probably feel like you have been taking all your scholastic life. The GRE is, in fact, the *last* of these. Most graduate programs require you to take the GRE; therefore, you should take it in your junior year so the scores are ready when you send out your applications to graduate school in your senior year. Even if you plan on working for a year or two before going on to graduate school, it is a good idea to take the GRE.

As you may already have discovered, some folks seem do well naturally at these generalized examinations, others typically do poorly. It is not at all clear that any of these test scores are reliable predictors of scholastic performance at any level, or subsequent job performance. I don't recommend *studying* for this exam, nor do I recommend taking the practice exams that are available, officially or in the bookstores, unless you are chronically poor at such tests. Even then, a major effort including taking the practice tests probably won't change the outcome by much. In my experience, it is not likely that you are going to affect your performance favorably by putting out a major effort to prepare for these tests. A heavy "cramming" effort may impair your performance, in fact.

I also believe that too much concern for these scores is exhibited during selection of students for acceptance in graduate school. It is an "objective" score and it does permit some "filtering" of candidates, even if it is known not to be a particularly valuable selection criterion. Therefore, your GRE scores may influence whether or not you are accepted, or whether or not you are offered financial support. This is not right, in my view, but it is a fact of life. Most graduate schools require that you take this exam and submit your scores as part of your application. Grin and bear it; take the test, and I wish you the best of luck. I don't believe worrying about it is going to help you, so just take it and get it out of the way.

C. Letters of recommendation

No matter what your decision about graduate school might be, it is likely that you are going to need recommendations from your instructors and any others who might have some knowledge of your accomplishments as a budding professional. In some cases, this means that letters have to be written, putting someone's evaluation of your qualifications on paper for someone to use in making a decision about you. Unlike the GRE, I consider this to be one of the most important things you can do for yourself. It is in your interest to obtain *positive* recommendations from the most noteworthy professionals you can

get to agree to make a recommendation. That is, a favorable letter from someone well-recognized in the field is more valuable to you than a letter from a graduate student or a junior faculty member. Of course, as an undergraduate, you may have only limited opportunities to make contact with such high-level "big shots" in your field. Therefore, it behooves you to seek out such folks and try to develop an interaction on some basis: taking a class from him/her, or working in their laboratory, or helping them on some project of theirs, or whatever it takes. Obviously, you will need to excel in that class or whatever. It does you no good if the big shot decides you're a loser.

Also, as I've noted already, it really helps if you have some non-academic people you have worked for in the summer (or part-time during the school year) who can say good things about you. Having even one such recommendation will make your application stand out from the rest, since many of your peers won't have one.

Of course, a *negative* letter of recommendation will be a real liability, even if the letter-writer is a big shot. Perhaps it's actually *worse* when coming from a big shot. You need to discuss the situation with your prospective recommender and find out what he/she is likely to say about you, or at least find out the general sense of such a recommendation. This does *not* mean that a purely positive appraisal, with no mention of weaknesses, is an absolute necessity. Employers tend to distrust a recommendation with nothing but high praise. Your strengths and weaknesses as a student are not necessarily the same as those for a prospective employee, so it is tough to generalize about what might be fatal in a recommendation on your behalf, because it depends on what your prospective employer or faculty deem to be important. You certainly should not take the process lightly and ask just *anyone* to recommend you. The outcome could be disastrous to your prospects.

D. Getting employed

If you are definitely hitting the job market instead of graduate school, then you are going to have to investigate what the job potential for your chosen profession is. Hopefully, you have been doing this *before* your senior year! If you haven't done so earlier, then you have a lot to do and not much time to do it. You need first of all to find out *where* to search. What sort of jobs have recent graduates been able to find? Are those employers still seeking new hires? If not, are similar employers looking? Are there jobs available in local, state, or federal government agencies?

Once you have determined where to start looking, you need to put together the information package that most employers are going to need. Besides your transcript and your letters of recommendation, you need to have collected all the personal data about yourself that an employer is likely to ask for in an application: such things as an employment history (summer jobs, part-time jobs, etc.), especially in work related to your profession; any honors and awards you may have received, any accomplishments you might have achieved (again, especially career-related, but not *limited* to that), any extracurricular activities you may have participated in, financial status, personal data (such as Social Security Account Numbers, etc.). You will be accessing this information repeatedly as you fill out information and having it readily at hand (say, stored in a personal computer) is a real benefit.

You may also know that a well-done résumé is of real importance to your employment application. Although much of the information on a résumé is the same from one application to the next, it is useful to "adjust" your résumé slightly each time to emphasize the specific things that might pertain to a particular employer. For example, your academic honors might be more valuable to a research organization than to a service organization. Obviously, this requires you to know something about what your prospective employer really is looking for in an applicant.

E. The application

The résumé is just *part* of an application. Remember all that I told you about doing things during the summer besides going to school, those summer jobs to look over your profession? Well, if you actually *did* those things and if you are still interested in pursuing the profession, those jobs will help your application stand out from the crowd. I'm assuming that only a fraction of you will ever follow my advice to the letter. Anyway, what you want to do with your application is toot your own horn (the letters of recommendation are a chance for *others* to toot your horn), to show a prospective employer why they should hire you and not the other applicants. Now is the time to show them that you are different, and worth noticing. Applications often ask you questions about things you've done. Your Eagle Scouting award, your summer job performances (assuming they were at least worth mentioning!), your baseball skills, your service to the school or community or whatever, etc. may be of interest and fit within the questions on an application. It may be that your computer programming skills or language proficiency are potentially valuable. If you became a licensed pilot, or an amateur radio operator, or an electrician, or

something that required you to demonstrate knowledge and skill, this might be useful to an employer. This is especially true if there is a connection to your profession. The whole point is to make your application stand out, to emphasize your strengths, so that you can get on to the next step: an interview.

F. Job interviews

A personal interview is typically the result of having *passed* a preliminary screening process; if the prospective employer asks you for an interview, this means that your application looked good enough for them to invest some time in looking at you. There are two very important things to remember about an interview.

First, the interview is an important part of getting employed. The impression you make will in all likelihood determine whether or not you are going to get offered a job. Do not take this lightly! You do not necessarily need to dress up formally to make a good impression, but showing up without a shave and/or a bath over the last several days and in a dirty t-shirt, cut-offs, and sandals probably will not do you much good. Indeed, what you say *is* more important than how you look, but a sloppy appearance does say bad things about you as an employee.

It is probable that you will be nervous, and the interviewer will understand that, but you should make honest statements about what you think and want from a job as a scientist or engineer. Acting as if you have no goals or desires other than what the organization asks of you is not likely to create a good impression. This brings me to the second important thing about an interview.

Second, remember that you need to find out something about *them* as much as they need to find out something about you. *An interview that lands you a job with a company that you come quickly to detest is not really a successful interview*. It is important that you try to see whether or not you *want* to work for that particular employer, as they see whether or not they want you to work for them. Therefore, if an interview results in your both agreeing that working for that employer is not right for you, then it was a *successful* interview. Both sides agree that you would be better off working for someone else, so that's not a bad outcome.

You ought to have some interest in an employer's package of benefits (health insurance, paid time off, retirement plan, etc.), but it is not a good idea to focus on those issues very intently. You are not creating a positive situation for yourself by being overly worried about the retirement package before you've

even *started* working there! Salary is a non-trivial issue, naturally, but you might need to be willing to start at a less-than-handsome salary. Employers rightfully treat students as unproven performers, and may be willing to promote quickly those who *demonstrate* their value to the organization, once they're on the job. Asking questions about professional advancement and how it works is a quite legitimate and important concern. You need to know about the availability of various training programs, as well.

A clear path of entry into employment is to take advantage of any "student trainee" programs that employers might offer, especially during the summer. This gives them a chance to look at you and gives you a chance to look at them. A successful experience makes everyone feel better about your working there after graduation. I recommend seeking out such opportunities as vigorously as you can, as early in school as you can. Ask your professors, advisors, and counselors to help you find out about such situations.

G. Making sure you're done

With the winding down of your undergraduate college career, it would not be pleasant to discover in what you think is your last semester that you have some unfulfilled requirement. It's prudent as you enter the fall term of your senior year to have your transcript checked to make sure what remains to be completed among your degree requirements. When I was in college, the university provided a service called a "Senior Summary" where an audit of my transcript was done and a listing of any remaining requirements was given to me. This was good insurance against unpleasant surprises. See if something of the sort can be provided to you. If nothing else, check your transcript against the degree requirements list often and ask your academic advisor to confirm your assessment of the situation.

H. Searching for graduate schools

Should you have opted for graduate school, there are many factors to consider as you think about *where* to apply. Chances are that if you are graduating, a good option is to go ahead and apply to your undergraduate institution, if they offer a graduate program. It may not be where you *want* to go, but unless you detest the place, it's a good fallback position. However, I do not recommend going to the same school for all your degrees. It's good to change the scenery at least once during your college days, and a typical time to do that is after you get your Bachelor's degree. Staying in the same place means you will get only

one view of the professional world you are about to enter. It helps to go somewhere else and see how they think about things. Graduate programs usually involve a higher degree of specialization than your undergraduate curriculum, so a major factor in selecting programs is knowing that the schools of your choice in fact have someone on the faculty who's *interested* in the same things you are.

Another factor is *financial support* during grad school. Although it may be possible to support yourself at a minimal level (assuming you're not financially independent), most of you will be seeking financial support for your graduate studies. There are two basic types of support: teaching assistantships and research assistantships (RAs). You will be familiar with TAs by now; the shoe will be on the other foot, though. Basically, the *department* will pay you to be a TA for some professor's course. You will get to lead discussion sections, grade papers, lead laboratory exercises, etc. Being a TA is a really good experience, and I recommend it for everyone, not just those who don't get an RA. Having to explain a subject to undergrads is a great way to find out what you *don't* know about that subject and your grasp of the course material will grow by leaps and bounds, if you care at all about the quality of your teaching.

RAs are offered mostly by *individual professors* and they are paid for by the grants those professors have received. Basically, you are being supported in exchange for doing the hard labor of research for the professor. In many cases, that research will be the basis for your thesis, but things do not necessarily work out that way. This must be negotiated with the professor offering the assistantship.

In either case, it is common at state-supported universities for you to get your out-of-state tuition paid for through the assistantship, assuming you are not a resident of the state. Of course, how this often works is that you pay the full tuition up front at the start of the academic semester/quarter, but you get repaid the difference over several paychecks. This can be a real challenge to your financial juggling skills. Most institutions that give you an RA or TA will not be happy if you have additional outside employment.

There are almost always free-ride scholarships available, but (a) they often have a "financial need" criterion that most middle-class families can't begin to meet, and/or (b) they usually require you to walk on water, academically. There aren't many of these and they only go to the select few.

You probably should apply to at least three grad schools, including the one from which you're graduating (if that's appropriate). Don't hesitate to apply to schools even if you're not sure you can get in. If you don't apply, they *definitely* won't let you in. Should you be accepted for admission, this does *not* mean you will be offered financial aid. In such a case, you're on your own and that may be a challenge all

by itself. If you do get accepted and *are* offered an assistantship at one school, it is probable that you will get similar offers from all the schools to which you applied. Then you have a decision to make. Remember, when you have to make such a decision, all the options are good. The chances are quite good that no matter how you make such a decision, it probably will turn out all right. A much more difficult decision is when you have to choose among *bad* choices, so don't feel too bad. Make a choice according to whatever your criteria might be and just get on with it. Don't agonize over the deal too long.

It may well turn out (and Murphy's Laws suggest it usually *will* turn out) that you get nice offers from everyone early, but your favorite choice is slow to reply. Most of the offers you'll get have limited times in which you can make your choice and if you haven't heard from that special choice of yours yet, then you may have to make a tough decision. Go ahead and contact the schools making the offers and see if they can wait a few extra days; explain the situation to them and many of them will be willing to delay the deadline some. Just don't push it too far. You still may have to make a tough choice whether or not to turn down a sure thing for a chance to go to your favorite school. I can't offer any clear-cut path through this, but remember that the most important factor in your education is *you*. With the proper attitude, you can get a great graduate education almost anywhere.

I. Your transcript's role

No matter what your post-graduate intentions are, graduate school or a job, your transcript is going to be a factor in your evaluation. There is little doubt that an above-average grade point is an important plus for you. However, in these days of grade inflation, both employers and graduate schools are less likely than ever to place an overriding emphasis on your G.P.A. If you took a light course load in order to get good grades, but took an extra semester (or especially an extra year!) to finish, it will be obvious to those looking at your transcript that you didn't really extend yourself to get those grades. Thus, they will not be as likely to be impressed with that 4.0 G.P.A. (or 3.9, or 3.8). In the same way, if you got your best grades in English or Basket-Weaving or Tennis and that offset your mostly Cs and a few Bs in your professional courses, then that high G.P.A. just doesn't sparkle very brightly. By the way, if you took longer because you had to *work* to support yourself and took a lighter load as a consequence, this will be a big *plus* in most employer's eyes!

By the same token, if you took the tough courses, and dropped down to Bs or even an occasional C

in the challenging subjects, this doesn't mean that your transcript is an embarrassment. Many prospective employers are able to "read" a transcript. If you got a bad grade in a key course because of personal problems or a conflict with the instructor, and that grade doesn't seem to be consistent with the rest of the transcript, a thoughtful employer probably will ask you about these anomalies in an interview. Also, if your first year or two weren't that good, but you improved markedly toward the end of your program, this often is considered favorably. If an employer is going strictly by the overall G.P.A., then you might in fact be better off *not* working for them!

Basically, a 4.0 transcript isn't a guarantee of anything, and a 3.25 transcript isn't cause to give up your science or engineering plans and enroll in the hometown vo-tech as a stenographer. I've already talked about what I consider to be a proper attitude toward grades: learn everything you're supposed to (and more!) and grades are nothing worth thinking about. The situation takes care of itself, if you take care of business. Stay on track toward your career in science or engineering, and your transcript just becomes another formality.

VIII. Closing Comments

Going into college seems like a big step at the beginning, and at the end it is quite possible to feel a bit let down. After all, for many of us, the time passed rather quickly and when we get that piece of paper, we may not feel all that different than when we went in. For the most part, that feeling is an illusion; the changes in us really were profound. It's just that it will take some time before that becomes apparent, and then it will only be in retrospect. For the time being, if you have completed your four years, take my word for it: you certainly are quite changed from what you were, especially if you have approached the program more or less as I have recommended.

Undergraduate school is a time of transition and if you have prepared yourself during that time to go on to the next phase of your life, be it work or graduate school, then the effort will be more than worthwhile. In fact, the effort should be fun. If you're not having fun in school, then something is wrong. Being in science and engineering carries with it enough challenges that most folks won't undertake the programs if they don't imagine themselves enjoying the process. So if you're not having fun, it's a signal that you need to reconsider and, possibly, re-evaluate your situation. I've tried to say it many times: there is no disgrace with deciding that science or engineering is not for you. Be glad that you found out before it

was too late. Unfortunately, the process fails for some, and they spend whole careers in science or engineering doing things they detest. What bothers me about that, apart from the misery that these sad cases create for themselves (and others), is that there were those who really wanted the spot occupied by the "reluctant dragon." If it were allowed that I could do something with such cases, I would push them out the door as quickly as is humanly possible, and make room for someone who is sincerely excited about doing something of substance in the profession. If your choice is to bail out, you have *my* whole-hearted support, because then someone down the road will not have to put up with your unhappiness.

I like being surrounded by excited folks, who love what they do and who can't wait to come to work in the morning. If this book can help you create a situation where you can become successful in science or engineering and truly enjoy what you are doing even half as much as I do, then it will have more than repaid what effort it has taken to write. I wish you the best in your professional careers and leave you with this thought: your professional life is virtually entirely in your hands to mold, for good or ill. Taking responsibility for that as an undergraduate will be the first but perhaps the most critical step in the process.