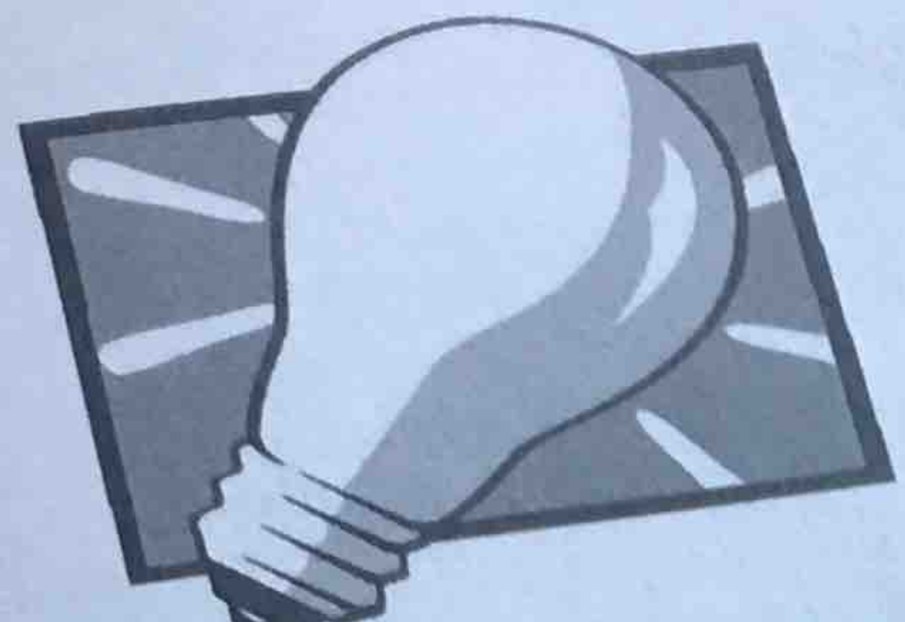


CHAPTER 5

Making the Learning Process Work For You

To improve is to change. To be perfect is to change often.

— Winston Churchill

INTRODUCTION

In Chapter 3, we provided overviews of how your teaching is delivered and how your learning takes place. In Chapter 4, we presented approaches for taking full advantage of the teaching process. This chapter focuses on designing your learning process.

We begin the chapter by discussing two important skills for learning – reading for comprehension and analytical problem solving. Your effectiveness as a learner will depend to a great extent on how well you develop your skills in these two areas.

Next we examine powerful principles and approaches for organizing your learning process. The importance of keeping up in your classes is discussed and steps for mastering the material presented in each class are presented. Mastering the material presented in a class before the next class comes requires a strong commitment to both time management and priority management, so we explore these important topics in detail.

We then describe approaches for preparing for and taking tests. Since the primary way you will be called on to demonstrate your learning will be through your performance on tests, it is imperative that you excel in this area.

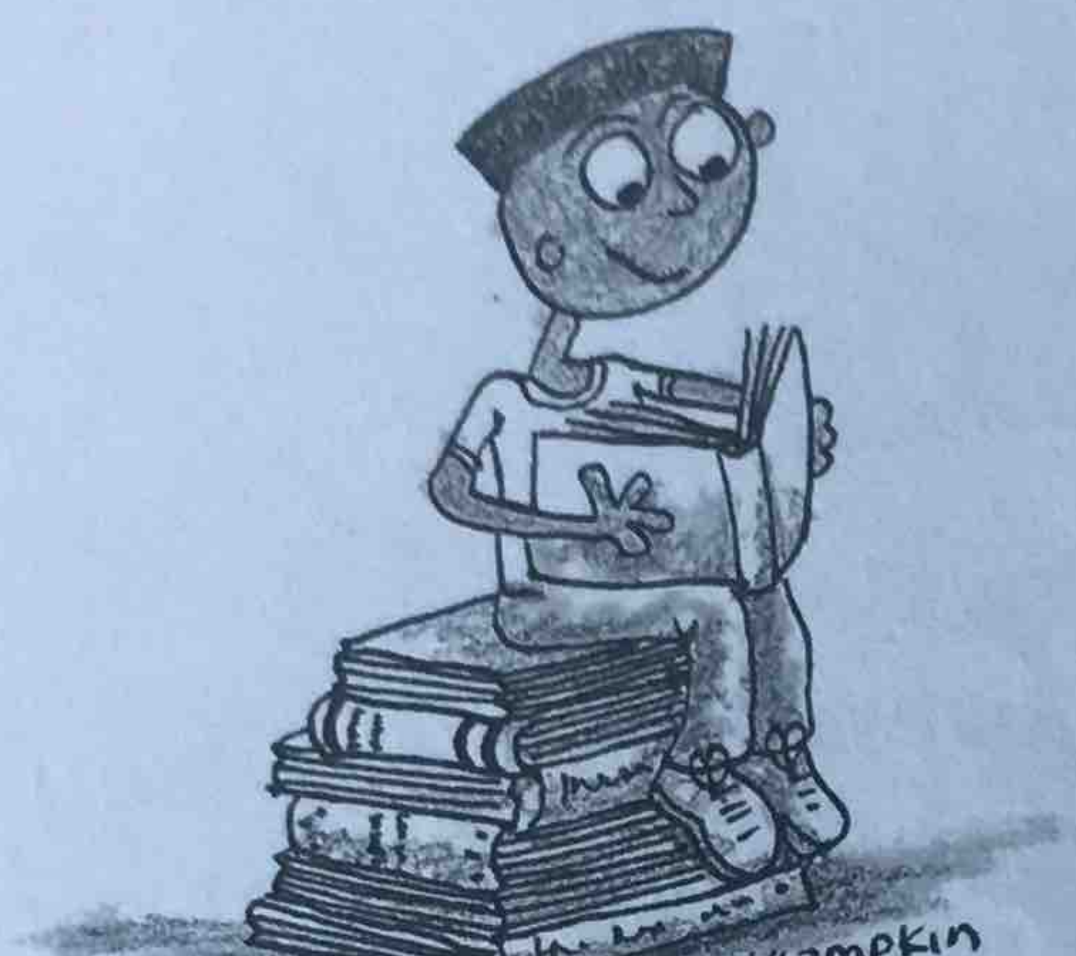
The chapter concludes with an in-depth discussion of making effective use of one of the most important resources available to you: your fellow students. Working collaboratively with your peers, particularly in informal study groups, sharing information with them, and developing habits of mutual support will be critical factors in your academic success and the quality of education you receive.

5.1 SKILLS FOR LEARNING

We begin this chapter by discussing two important skills for learning: (1) reading for comprehension and (2) analytical problem solving.

READING FOR COMPREHENSION

Much of your learning will depend on how well you understand information presented in written materials. And you can expect that much of this material will be highly technical in nature. In fact, a typical four-year engineering curriculum will include about three years (96 semester credit hours) of technical courses (math, physics, chemistry, engineering, computing) and one year (32 semester credit hours) of non-technical (humanities, social science, communication skills) courses.



Although the methodology you learn in this section can be applied to both your technical and non-technical courses, it is particularly important for your technical courses.

One important difference in reading technical material is "speed." You may equate having "good" reading skills with being a fast reader and even consider taking a "speed reading" course. Speed reading may be helpful in reading a novel for pleasure or for reading the morning newspaper, but trying to read too fast may work against you in your technical courses. Mastering mathematics, science, and engineering content is generally a slow, repetitive process that requires active participation on your part.

There are a number of methodologies for reading for comprehension. All involve developing your skills in three areas:

- What you do ***before*** you read
- What you do ***while*** you read
- What you do ***after*** you read

Before You Read. The amount you learn from a reading task can be greatly enhanced by taking a few minutes to do three things before you start reading:

1. **Purpose** – Establish a purpose for your reading. The purpose might be entertainment or pleasure. Or it might be to find out one single piece of information. However, in technical courses, more often than not the purpose is to comprehend principles and concepts that will enable you to solve problems at the end of a section or chapter in a textbook.

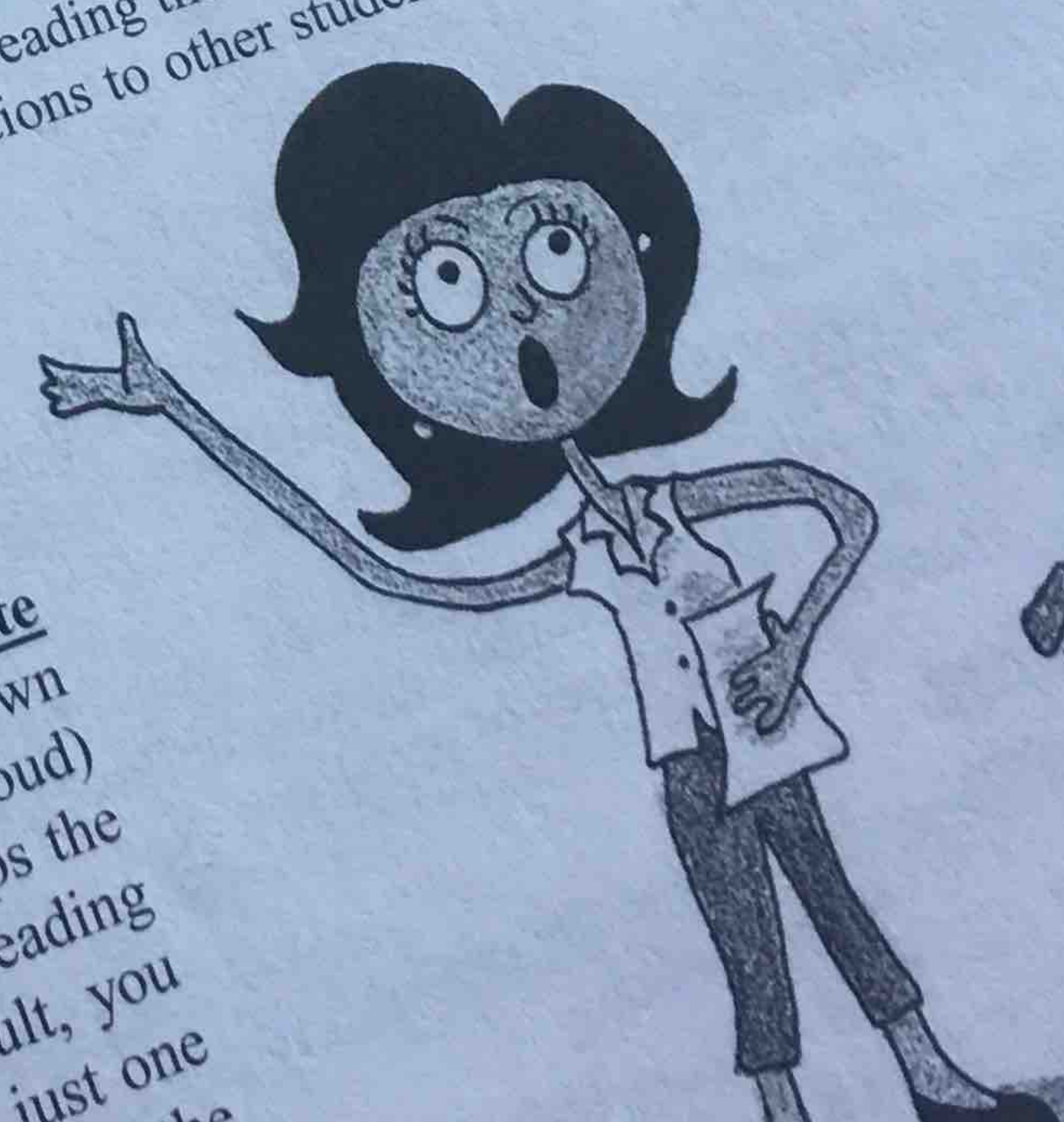
2. **Survey** – Decide on the specific scope/size of the reading (one page, one section, one chapter). Devote a few minutes to survey/skim/preview that page, section, or chapter. Look at headings and subheadings. Inspect drawings, diagrams, charts, tables,

figures, and photographs. Read the introductory section or paragraph and the summary section or paragraph.

3. **Question** – Write down questions that you want to answer from the reading. A useful technique is to turn section headings and subheadings into questions. For example, some questions you might have written down for this section are: What do I need to learn to do before I read? What are the benefits of doing these things? What are some of the things that might keep me from doing them?

WHILE YOU READ. Following is a list of suggestions for improving your comprehension when reading technical material.

- Never sit down to study without a paper and pen or pencil at hand. You'll need them for sketching graphs, checking derivations, summarizing ideas, and raising questions. This approach to active reading is very important.
- Focus on concepts, not exercises or problems. The goal of most technical coursework is to enable you to understand concepts that can be applied to a variety of problems. Rather than focusing on how one particular problem is solved, first aim to understand the general concepts thoroughly. Pay close attention to the mathematical formulas. Work carefully through each derivation. Take time to absorb graphs and figures. One of the biggest mistakes students make is to skim over the material in order to get on with the homework problems. Don't truncate the learning process in your rush to get an assignment done.
- Don't try to read too quickly. In a half hour, you might read 20-60 pages in a novel. But expect to spend the same half hour on just a few lines of technical material. (Mathematics says a lot with a little!) Become an active participant in your learning process. At every stage, decide whether the concept presented was clear. Ask questions. Why is the concept true? Do I really understand it? Could I explain it to someone else? Do I have a better way to explain it?
- Write down anything that you don't understand. Where possible, frame it in the form of a question. Seek to answer such questions by re-reading the text or using alternate sources such as other textbooks or the Internet. Pose the questions to other students or to your instructor during his or her office hours. As you read, there may be questions that pique your curiosity but are not answered in the reading material. Take on the challenge of finding the answers to these questions.



- Periodically stop reading and **recite** what you have read. Using your own words, repeat to yourself (ideally aloud) what you have read. This is perhaps the most important step in the reading process. If the material is difficult, you may want to recite after reading just one paragraph. By reciting, you implant the knowledge in your brain. Do not look at the book as you recite. If you can't remember what you read, reread the material.

AFTER YOU READ. Once you have read your text, most of the learning is still ahead of you. The following are three important tasks to perform after your reading: recite and reread, review, and solve problems.

- **Recite and Reread.** – Recall that during the process of preparing for your reading, you formulated questions you would like to have answered by the reading. Recite answers to those questions. If you need to, reread sections of the text. Again, it is preferable to recite aloud. Even better, recite to others. One of the best ways to learn anything is to teach it to someone else. Form a study group or meet with a study partner and practice teaching each other what you have learned from the reading (more detail on group study is covered in Section 5.4). You can even tell friends and family members what you are learning. Talking about what you have learned is a powerful way to reinforce it.
- **Review** - Recall from Chapter 3 that learning is a reinforcement process. Only through repeated exposure to information can we move it from our short-term memory to our long-term memory. Plan to do your first complete review within one day. Review the important points in the text and recite some of the main points again. Do it again in a week and then when you prepare for a quiz or exam and again when you prepare for the final examination.

- **Solve Problems** - Once you have read your text for comprehension, it's time to work problems. Being able to solve problems with speed and accuracy is to a great extent what you will be judged on in your math/science/engineering coursework. This requires both a systematic problem-solving approach and lots and lots of practice. You can't work too many problems. First do any assigned problems. Don't stop there though. If possible, work all the problems in the book. If you still have time, work them again.

Most of the problems you will encounter in math/science/engineering coursework can be described as "analysis" problems. Because of the importance of this type of problem in your education, the next section discusses a methodology for analytical problem-solving.

Before you read on, go to the next page and try the exercise to illustrate the principles of reading for comprehension.

PROBLEM-SOLVING

Engineers are problem-solvers. Much of your engineering education, and indeed your engineering career, will center on improving your ability to think both logically and creatively to solve problems. There are many types of problems. Some examples would be:

Type of Problem	Example
Mathematics problems	Determine the probability that two students in a class of 30 have the same birthday.
Science problems	Find a theory that explains why a dimpled golf ball travels further than a smooth one.
Engineering analysis problems	Find the stress in a beam, the temperature of an electronic component, or the voltage at a node in a circuit.

Engineering design problems	Design a better mousetrap, a car alarm that goes off if the driver falls asleep, a better device for waiters and waitresses to carry plates of food from the kitchen to the table.
Societal problems	Propose a systematic solution to global warming, immigration, health care, or world hunger.
Personal problems	Solve health problems, financial problems, or relationship problems.

EXERCISE

Apply the reading methods you have just learned to the following passage:

Shortcut For Adding Consecutive Numbers Starting with 1

The following theorem was published in Levi Ben Gershon's 13th century manuscript *Maaseh Hoshev (The Art of Calculation)*:

"When you add consecutive numbers starting with 1, and the number of numbers you add is odd, the result is equal to the product of the middle number among them times the last number."

In the language of modern-day mathematics, this is written as:

$$\sum_{i=1}^{2k+1} i = (k+1)(2k+1)$$

Before reading, did you establish a purpose? Did you first skim the passage? Did you write down any questions you wanted answered? During reading, did you follow any of the suggestions made in the previous section? Most importantly, did you recite what you learned? Can you apply the theorem? For example, how quickly can you add all consecutive numbers from 1 to 99? What level of understanding did you achieve? What does the symbol "k" represent? Can you find a better way to represent the theorem mathematically? Were any questions that piqued your curiosity? Do you want to know more about the life and work of Levi Ben Gershon? Did learning about this theorem interest you in other similar theorems?

General Problem-Solving Methodology. Because there are so many types of problems, there are many different problem-solving methodologies. For example, you undoubtedly learned in high school about the scientific method in which a hypothesis is developed to explain some observed physical phenomenon and then tested through experiment. You also learned about the engineering design process in Chapter 2 of this book. Both are specific problem-solving methodologies.

A general approach for solving problems involves the following steps:

- Figure out where you are (problem definition).
- Figure out where you want to be (e.g., customer need or business opportunity).
- Determine what resources are available.
- Identify any constraints.
- Develop possible solutions that could solve the problem while staying within available resources and not violating any of the constraints.

- Choose the best solution.
- Implement it.

If you master this problem-solving approach, you will not only be able to use it in your work as an engineering professional, but also in all aspects of your personal life. It can be applied to such varied problems as buying a new TV, dealing with your car breaking down in the middle of nowhere, finding a job, running for president of your engineering student organization, starting your own company, or stopping the re-zoning of an area of your neighborhood.

All of these examples and most real engineering problems can be described as open-ended problems, meaning that they have no single right answer or solution.

ANALYSIS PROBLEMS. Much of your engineering education, however, particularly in the first several years, will not deal with open-ended problems but rather will focus on "analysis problems." Generally, analysis problems have one single right answer. They typically involve translating a physical problem into a mathematical model and solving the resulting equations for the answer. The problem statement will be provided to you by your instructor either in the form of a handout or a problem from your textbook. The principles you need to solve the problem will typically be contained in your text material, although you may need to draw on knowledge from prerequisite courses. Your success in engineering study will depend to a great extent on your ability to solve such problems accurately and often under time pressure.

Real-world problem-solving is, for the most part, not a science but rather an art. It involves learning, thinking, logic, creativity, strategies, flexibility, intuition, and trial and error. Even so, becoming a proficient analytical problem-solver can best be accomplished if you adopt, practice, and become proficient at the following four-step systematic approach (adapted from famous mathematician George Pólya) [1]. This approach is not an algorithm (i.e., a series of steps that if applied correctly are guaranteed to lead to a solution) but rather a *heuristic* (a general set of guidelines for approaching problem-solving that do not guarantee a solution).

Step 1: Understand the problem. Read the problem carefully. Identify the question you are being asked to answer. Identify the unknown(s) and assign each unknown a symbol. List all known information. Draw a figure, picture, or diagram that describes the problem and label it with the information you have extracted from the problem statement.

Step 2: Devise a plan. The goal of this step is to find a strategy that works. Because there are many possible approaches, this is perhaps the most difficult step in the problem-solving process. Think about possible relationships between the known information and the question you need to answer. Depending on the nature of the problem, the following is a list of problem-solving strategies to try:

Solve a simpler problem.
Make an orderly list.
Look for a pattern in the problem.
Draw a diagram.
Use a model.
Use a formula.
Work backwards.
Make a table.
Guess and check.
Eliminate possibilities.
Solve an equation.

Use direct reasoning.
Consider special cases.
Think of a similar problem.
Solve an equivalent problem.

Step 3: Carry out the plan. Implementing the plan depends on the nature of the problem and the problem-solving strategy chosen. In all cases, work carefully and check each step as you proceed. By the time you reach this step, you should have reduced the problem to a purely mathematical one. Work through each step of any mathematical manipulations or derivations. Complete any required calculations using an electronic calculator or computer. Take particular care to ensure correct handling of units, a frequent source of errors in engineering problem-solving.

Step 4. Look Back. Examine the solution you obtained. Make sure it is reasonable. Recheck your calculations and review your reasoning. Verify that your answer is consistent with the information given.

As you become better and better at solving problems, let's hope you don't reach the point shown in the following cartoon.

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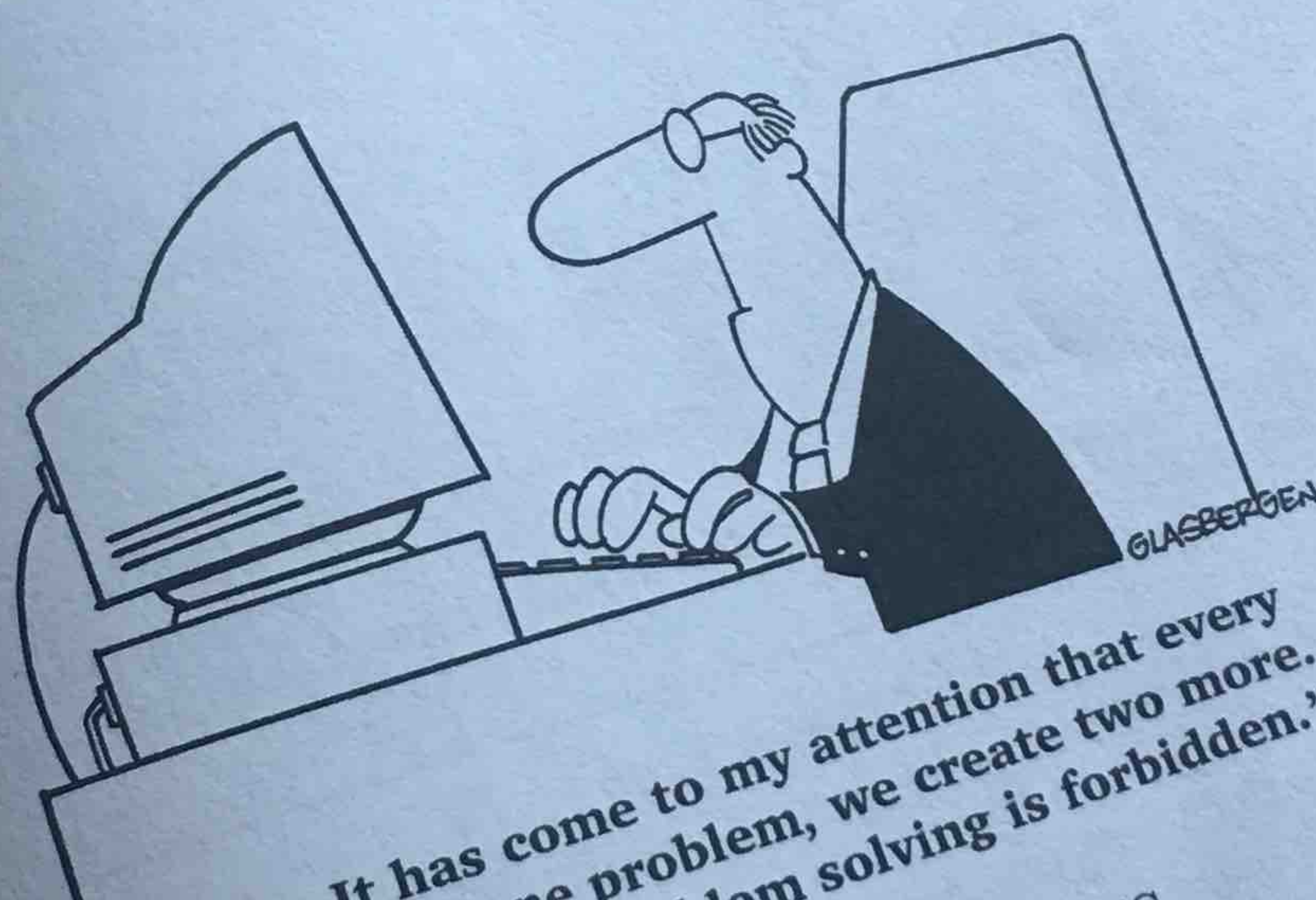


"MEMO: It has come to my attention that every time we solve one problem, we create two more. From now on, all problem solving is forbidden."

5.2 ORGANIZING YOUR LEARNING PROCESS

In the following sections you will learn about ways to organize your learning process.

"TAKE IT AS IT COMES"

I use the expression "take it as it comes," an axiom you've undoubtedly heard before, to emphasize what I consider to be the KEY to success in mathematics, science, and engineeri[ng] courses. Stated more explicitly:

> **Don't allow the next class session in a course to come without having mastered the material presented in the previous class session.**

Because, to me, this is the single most powerful academic success strategy, ***if you are willing to put only one new behavior into practice, this is the one to choose!***

Have you ever wondered why a typical course is scheduled to meet only one, two, or three times a week rather than all five days? And why the total weekly hours of class meetings are so limited? After all, if you met nine hours a day for five straight days, you could theoretically complete an entire course in one week and cut down the time to complete your undergraduate degree from four years to less than one year!

The answer is obvious. The teaching part of the teaching/learning process could be compressed into one week but certainly not the learning part. You can only absorb a certain amount of material at one time, and only when that material is mastered can you go on to new material. Thus, your institution has designed a sound educational system in which professors sequentially cover small amounts of material for you to master. However, unless you do your part, you can easily turn that sound educational process into an unsound one.

REFLECTION

Reflect on your approach to your classes. Do you operate on the principle that you master the material presented in each class before the next class comes? Or do you put off studying until a test is announced and then cram for it? If you are in the second category, are you willing to change? What do you need to do to make that change?

PROCRASTINATION

Most students make the mistake of studying from test to test rather than from class to class. In doing so, they fall victim to a student's greatest enemy – procrastination.

Procrastination is an attitude that says, "Do it later!" "Doing it later" rarely works in any course, but especially not in math, science, and engineering courses, in which each new concept builds on the previous ones.

If you are a procrastinator, for whatever reason, you are likely to ignore the sequential nature of engineering study, somehow thinking that you have the capability to absorb complex information all at once. So you can't realistically expect to succeed if you delay your studying until a test is imminent. That's why I tell you to "take it as it comes."

A Common Trap

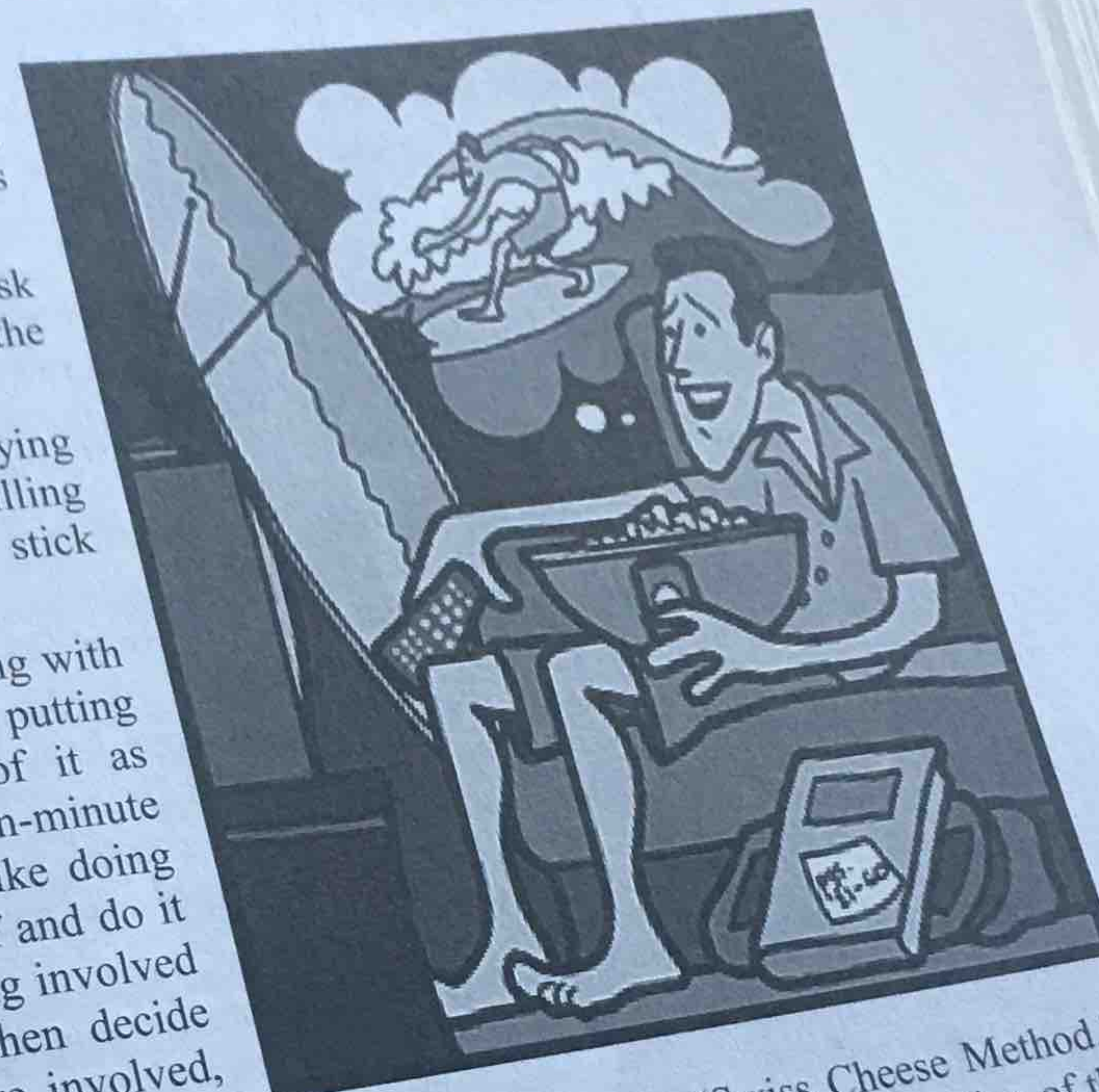
One trap you can fall into is a false sense of security because the teacher presents the material so clearly that you feel you understand it completely and therefore do not need to study it. But when you attend a lecture that is presented clearly, it only proves that the teacher understands the material.

What is necessary is for you to understand it – for you to be able to give the lecture. In fact, that should be your goal in every class – to get to the point where you could give the lecture.

Often I am invited to be a guest speaker at *Introduction to Engineering* courses that use this text. Because it's such an important topic, I always make it a point to address the subject of procrastination. Typically, I'll ask the class: "How many of you would say – 'I am a procrastinator'?" To this day, I am surprised that not only do almost all the hands go up, but they go up enthusiastically (almost proudly). It seems as though there's pride in being a member of an undesirable club – the "Procrastinator Club."

You may think of procrastination as doing nothing. But we're always doing something. Ultimately, ***procrastination involves choosing to put off something we know we should be doing and instead doing something we know we shouldn't be doing.*** And why would we do such a thing? Why would we delay an action we know we should be doing? There are lots of reasons:

Fear of failure – Task is perceived as too difficult: "If we don't attempt it, then we haven't failed."



Fear of success – Accomplishing task might be resented by others, or success might bring responsibilities and choices that we view as threats or burdens.

Low tolerance for unpleasant tasks – Task is viewed as not being enjoyable. Doing the task may bring some discomfort.

Disorganized – Prefer to spend time worrying about not doing rather than doing. Unwilling to set priorities, develop a schedule, and stick to the schedule.

There are many strategies for dealing with procrastination. If you find you're putting something off because you think of it as unpleasant, a good approach is the ten-minute rule. Acknowledge, "I don't feel like doing that," but make a deal with yourself and do it for ten minutes anyway. After being involved in the activity for ten minutes, then decide whether to continue. Once you're involved, it's easier to stay with a task.

And if you're overwhelmed with the difficulty of a task, use the "Swiss Cheese Method." Poke holes in the big project by finding short tasks to do that will contribute to completion of the larger project.

Procrastination is a big subject, with many complete books devoted to it. If you are a chronic procrastinator, you might want to learn more about the subject by reading one or more books about it, e.g., [2,3,4].

REFLECTION

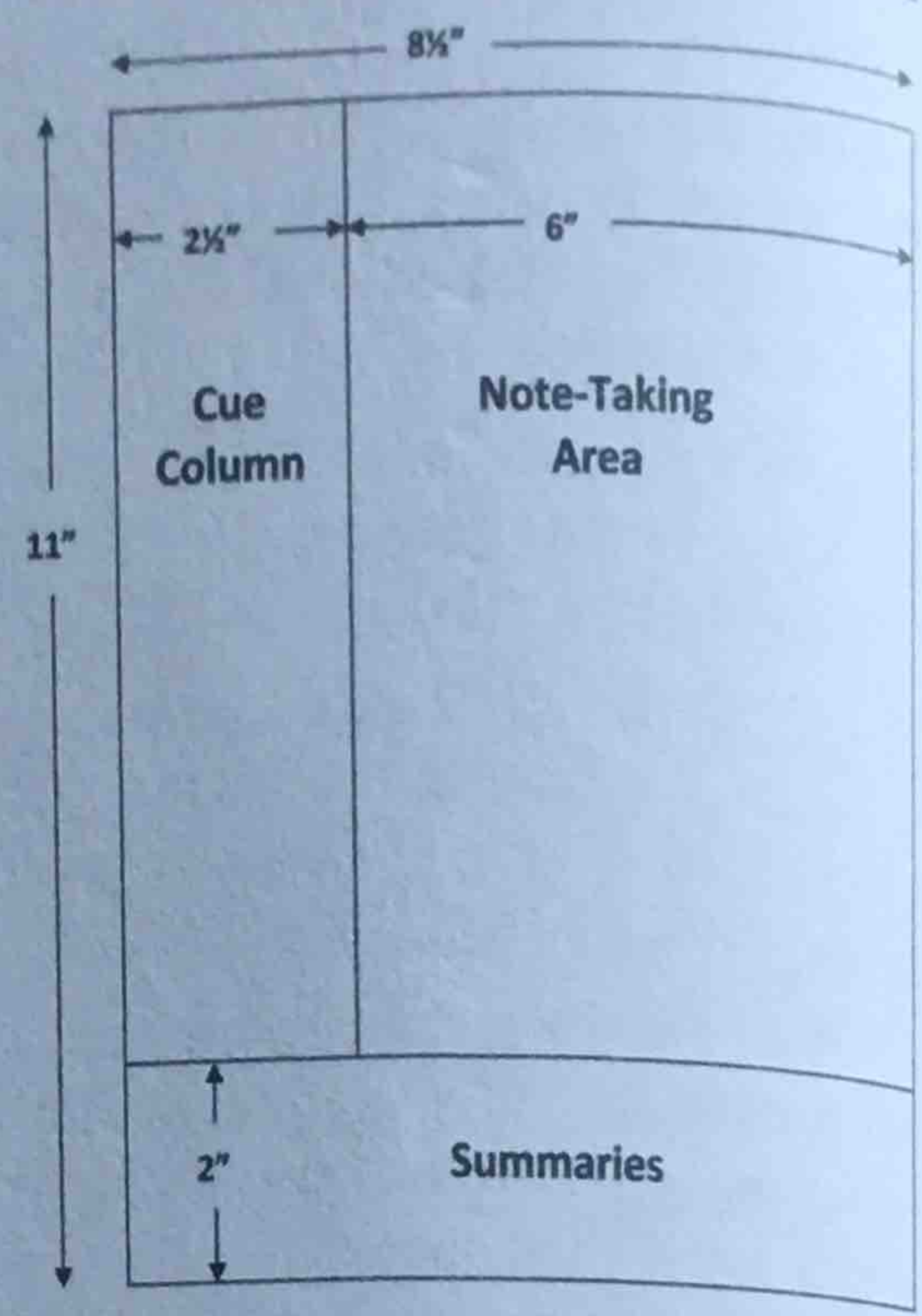
Recall one or two recent examples where you put off a task you should have done. Describe each task you put off. What were you thinking when you chose to put off the task? What were you feeling when you were procrastinating? Can you identify any discomfort you were avoiding by putting off the task?

MASTERING THE MATERIAL

As previously discussed, you will learn better if you "take it as it comes," mastering the material presented in each class session before the next session comes. In fact, research on learning indicates that the sooner you study after your initial exposure to the material, the more fortified your learning will be. Having a study session right after class would be ideal, but if that's not possible, doing it the same day would be better than the next day. Since your goal is to master the material, start by studying and annotating your notes, reading (or rereading) the relevant portions in your text, and working problems – as many as you can.

LEARNING FROM YOUR LECTURE NOTES. Recall in the section on the **Cornell Note-Taking Method** (Chapter 4, Pages 117-118), it was recommended that you structure your notes to leave two areas blank for use during your learning process:

(1) Cue Column
(2) Summary Area

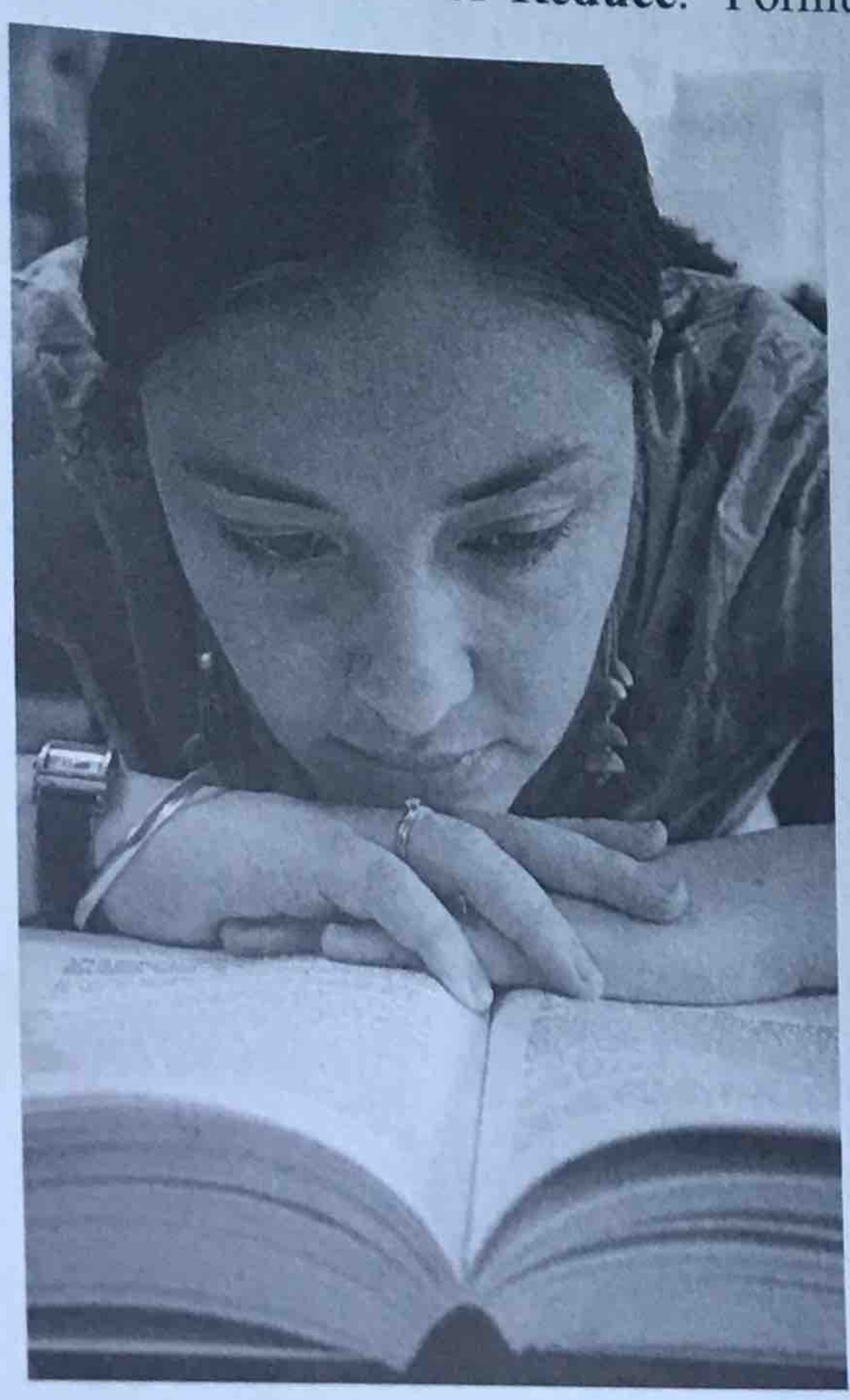


Now we will describe how you can take advantage of this new way of taking notes by adopting a systematic process for learning from them. The goal of this process is to increase your understanding of what was covered in class and to move as much as possible from your short-term memory to your long-term memory through repetition, review, and reinforcement.

The process of learning from your notes involves six separate but interrelated steps.

Step 1 - **Study and annotate your notes**. Read/Go over each page of your notes and fill in any missing information. Add words, phrases, facts, or steps in a derivation you may have skipped or missed, and fix any difficult-to-decipher jottings. As you study your notes, enliven them by making liberal use of colored pens or pencils. Highlight important points by underlining, circling or boxing, or using arrows.

Step 2 – **Question or Reduce**. Formulate a question answered by each major term or point in your notes and write it in the Cue Column. This is a little bit like the TV game show *Jeopardy* where the contestants are given the answer and asked to supply the question. An alternative approach would be to reduce each main idea or set of facts into a key word or phrase and write it in the Cue Column.



Step 3 – **Summarize**. Write a summary of each page in the Summary Area at the bottom. Summarizing forces you to think about the broader context of the lecture. Your summary should answer the questions: "What is this page about?" and "How does it fit into the day's lecture?" These summaries will be particularly helpful in finding key information when you are studying for an exam.

Step 4 – **Recite**. Once you have studied and annotated your notes and filled in the Cue Column and the Summary Area for each page, it is time for the most important step in your learning process: ***recitation***. The process of reciting is relatively straightforward. Go back to the first page and cover the Note-Taking Area with a blank sheet. Read the first question or key word in the Cue Column. If you wrote questions, answer each question in your own words. If you wrote key words, describe the main idea or set of facts referred to. Ideally, you should recite out loud. If you are reluctant or unable to do this, recite by writing out your answers. Slide the blank sheet down to check your answer. If your answer is wrong or incomplete, try again. Continue this process until you have gone all the way through your notes.

<u>Step 5</u> – **Reflect**. After you have completed the first four steps above, take some time to reflect on what you have learned. Ask yourself questions like, "What's the significance of what I have learned?" "How do the main ideas of this lecture fit together into a bigger picture?" "How do they fit into what I already know?" "What are some possible applications of the key ideas from this lecture?" "Which ideas are clear?" "Which ideas are confusing?" "What new questions do the ideas raise?"

<u>Step 6</u> – **Review**. Working through the process above will not only increase the amount you learn from your lectures and notes, it will also convert your lecture notes into study notes for future reviews. I suggest you review all your notes once each week. Doing so won't take much time but will pay off immensely in the long term. You'll find that if you spend just ten minutes to review your notes weekly, you'll retain most of what you initially learned. Then give your notes a more thorough review when you prepare for a test and then again when you prepare for the final exam. And don't forget to use reciting to reinforce what you have learned during each review session.

<u>READING/REREADING THE TEXT</u>. Next, read or re-read (*re-read* if you read the text to prepare for the lecture) the text material. Follow the "Reading for Comprehension" methodology described in Section 5.1. Resist your urge to skim over the material in order to get to assigned problems. Read or re-read to understand the concepts. And make reciting a key part of your reading process.

<u>SOLVE PROBLEMS</u>. As previously discussed, solving one or two problems, even if that's all your professor assigns, will not ensure an adequate level of understanding. If time permits, work <u>all</u> of the problems in the book. If more time is available, work them a second time. Practice, practice, practice! The more problems you solve, the more you will learn. Remember:

> ***Much, perhaps most, of the learning in math, science, and engineering courses comes not from studying or reading but from solving problems.***

To the extent possible, utilize the analytical problem-solving methodology described in Section 5.1. By doing so, you'll improve your problem-solving capability over time.

After you feel you have mastered the material, you can reinforce your understanding through a group study session or by going to visit your instructor during office hours to address specific questions or problems.

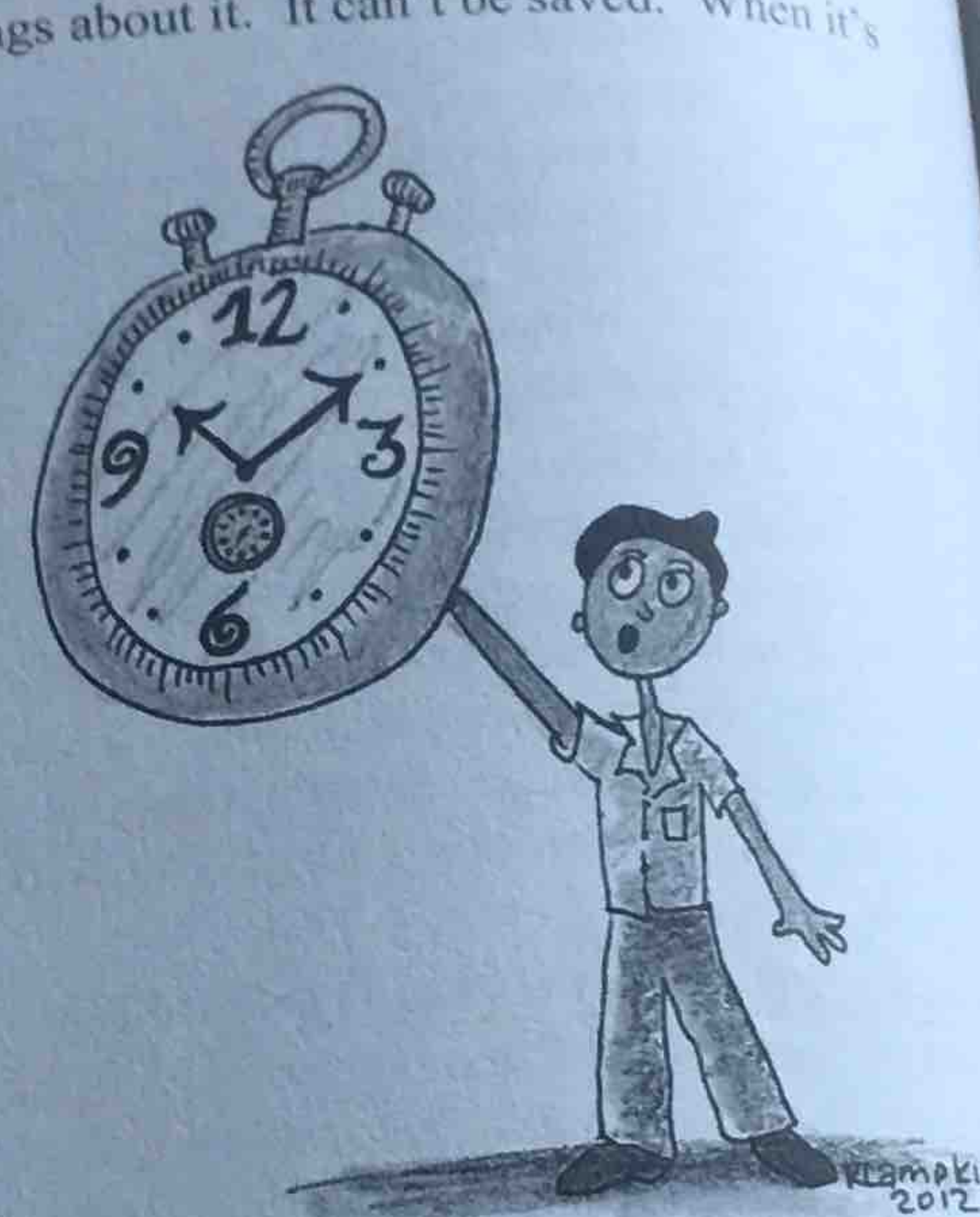
Only then will you be ready for your next class meeting. At that point, you will have reinforced your understanding of the material several times. Later you will again reinforce it when you review for a test and still later when you prepare for the final exam.

<u>LEARN TO MANAGE YOUR TIME</u>

Time is an "equal opportunity" resource. All people – regardless of their socioeconomic status, gender, ethnicity, physical challenges, cultural practices, or any other kind of "difference" – have exactly the same amount of time. Everyone, including you, gets 168 hours each week – no more, no less.

> ***There is no point in saying that you have no time, because, you have just as much as everyone else.***

Time is an unusual and puzzling concept. Even the most brilliant scientists and philosophers aren't sure how to explain it. But we do know some things about it. It can't be saved. When it's gone, it's gone. It also seems to pass at varying speeds – sometimes too slowly and other times too quickly. It can be put to good use, or it can be wasted. Some people accomplish a great deal with their time, while others accomplish virtually nothing with theirs.



People who accomplish a great deal, without exception, do two things:

(1) They place a high value on their time.
(2) They have a system for scheduling and managing their time and tasks.

Some of these systems are very sophisticated, and you may wish to look into acquiring one, particularly when you become a practicing engineer. As a student, you can do quite well with a monthly calendar to note your appointments and a simple form for making a day-to-day schedule. (See form on Page 160).

HOW MANY HOURS SHOULD YOU STUDY? Once you commit to staying on top of your classes and reinforcing your learning as often as possible, you must make sure to allot a sufficient number of study hours to truly master the material covered in a one-hour lecture. Earlier, in presenting the "60-Hour Rule" (See Chapter 1, Page 29), we mentioned the standard rule-of-thumb that you should study two hours out of class for every hour in class. But this is often a gross oversimplification or, at best, a very limited generalization. In actuality, the amount of study time required will vary from course to course, depending on such factors as:

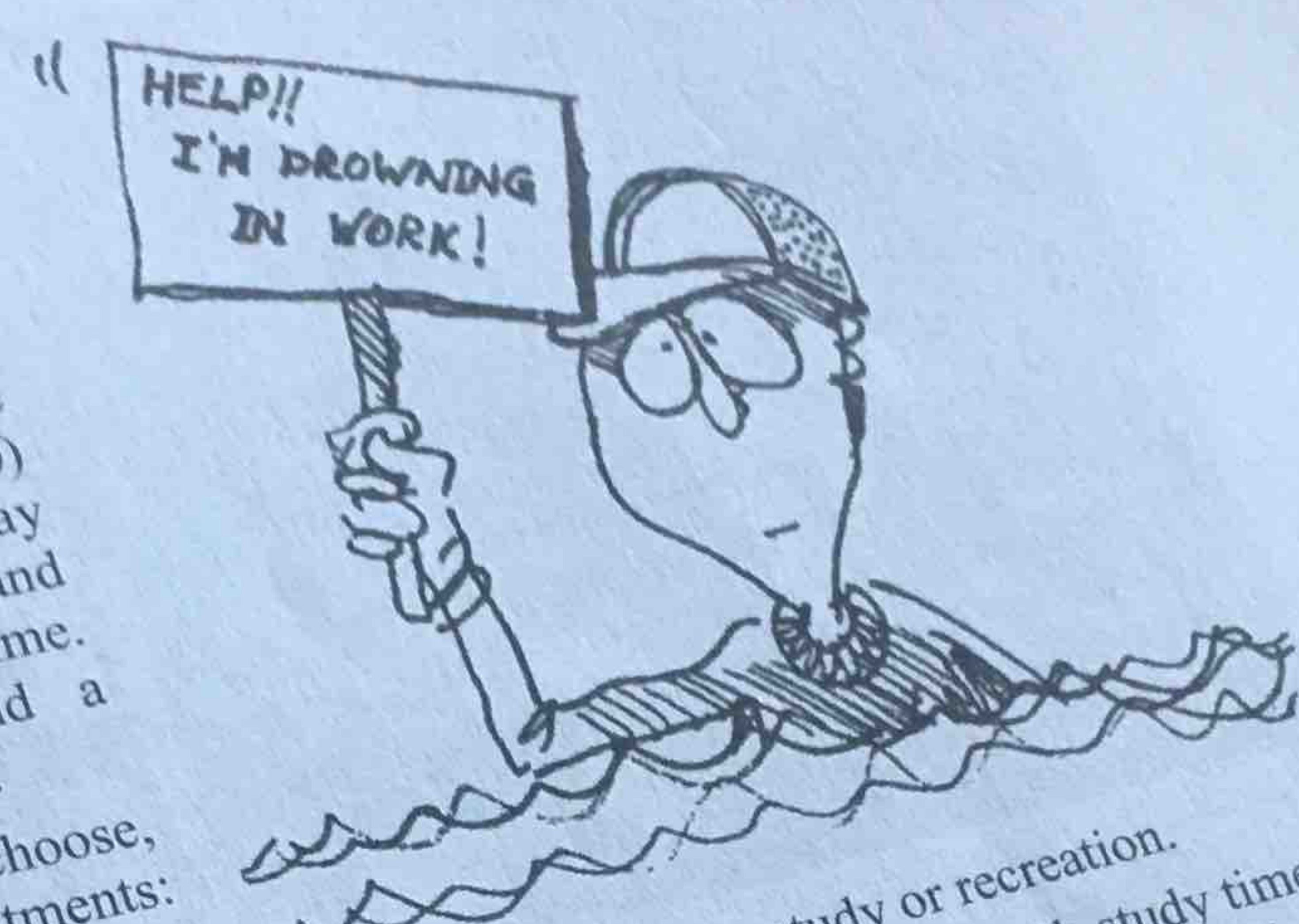
- How difficult the course is
- How good a student you are
- How well prepared you are for the course
- What grade you want to receive

For demanding technical courses, it is doubtful that two hours of studying for every hour spent in class are enough. The appropriate number for you may be three, four, or even five hours. Although this may be difficult to assess, especially early on in your education, it's good to determine a number for each of your classes. You can always adjust it later.

REFLECTION

On a scale of zero to ten, how good of a student are you? Reflect on each of your courses. How difficult is the course (very difficult, moderately difficult, not difficult)? How well prepared are you for the course? What grade do you want in the course? Based on this information for each of your courses, write down how many hours you need to study for each hour of class time.

Once you have decided that for a particular course you should study, say, three hours between one class meeting and the next, and you have blocked out a schedule for studying as soon after each lecture as possible, you have done the easy part. The hard part is actually doing it. Putting these approaches into practice requires you to be organized and skilled in managing your time.



MAKING UP YOUR WEEKLY SCHEDULE. Your effectiveness and productivity as a student will be greatly enhanced by scheduling your time. The approach I took when I was a student was to sit down each Sunday night with a form like the one shown at the end of this chapter (Page 160) and schedule my entire week. You may find that a whole week is too much, and prefer to schedule a day or two at a time. That's fine. The idea is to find a scheduling method that works for you.

For whatever time period you choose, first write down all your commitments: classes, meetings, part-time work, time to get to and from school, time for meals, and so forth. The rest of your time is available for one of two purposes: study or recreation.

Next, schedule blocks of time to study. You have already decided how much study time you need between one class meeting and the next, and you know the advantages of scheduling this time as soon after each class meeting as possible. Write down both <u>where</u> and <u>what</u> you will study. Students tend to waste too much time between classes making three decisions:

(1) Should I study now or later?
(2) Where should I study?
(3) What should I study?

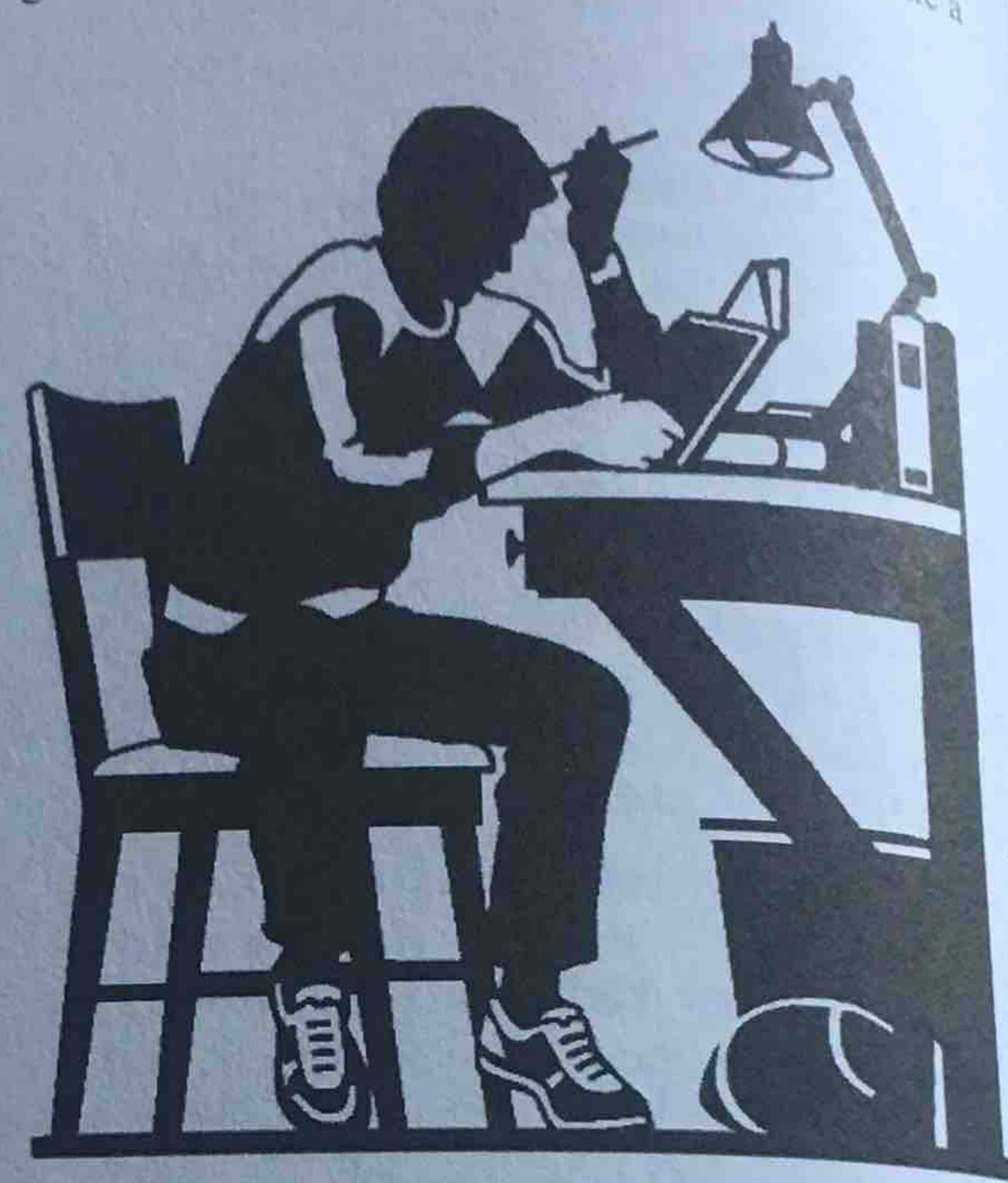
By making these decisions in advance, you will eliminate this unnecessary waste of time.

EXERCISE

Do you schedule your study time? If so, how is it working for you? If not, why don't you? Sit down with a form like the one on Page 160 of this chapter and schedule your time for the next week. After scheduling your commitments (class, work, appointments, etc.), schedule your study time following the principles presented in this section. Include information on both where you plan to study and what course you will focus on during each time block. Make a commitment to follow your schedule for the next week.

Once your study time is scheduled, check to see that you've left open time for breaks, recreation, or "down time." If not, you are probably overcommitted. You have taken on too much. One of the advantages of making a schedule is that it gives you a graphic picture of your situation. Remember, don't "program yourself for failure." Be realistic about what you can handle. If you are overcommitted, you should probably let something go. Try to reduce your work hours, your extracurricular activities, or the number of units you are taking.

MAKE A SERIOUS COMMITMENT TO YOUR SCHEDULED STUDY TIME. Making up a weekly schedule, you'll find, is easy and fun. But sticking to it will be a challenge. The key is to make a serious commitment to your study time. I'm sure you take your class time as a serious commitment. If, for example, five minutes before a class a friend asked you to go have a cup of coffee or a Coke, you would say, "Sorry. I can't because I have a class." But what about your study time? What if the same friend came up to you just as you were about to go to the library to study?



You need to make the same commitment to your scheduled study time as you do to your class time. After all, much more learning occurs out of class than in. It always astonishes me that students are so willing to negotiate away their study time. Every time you put off an hour of studying, you are giving up time that you cannot recapture, and that means borrowing time from the future. If, however, your future is already scheduled, as it should be, the notion of borrowing time from the future is impossible. You're talking about time that won't be there.

To monitor yourself, outline the hours you actually study in red on your schedule form. At the end of each week, you will be able to readily count up how much studying you did. If you are doing poorly in your classes, I'll bet you will see a direct correlation between your performance and the amount of studying you are doing.

Initially, you may find that you have made a schedule you are unable to follow. Don't beat yourself up over that. But, more importantly, don't use it as an excuse to give up scheduling your time completely. Over time, you will learn about what you can and cannot do and become more proficient at scheduling your time.

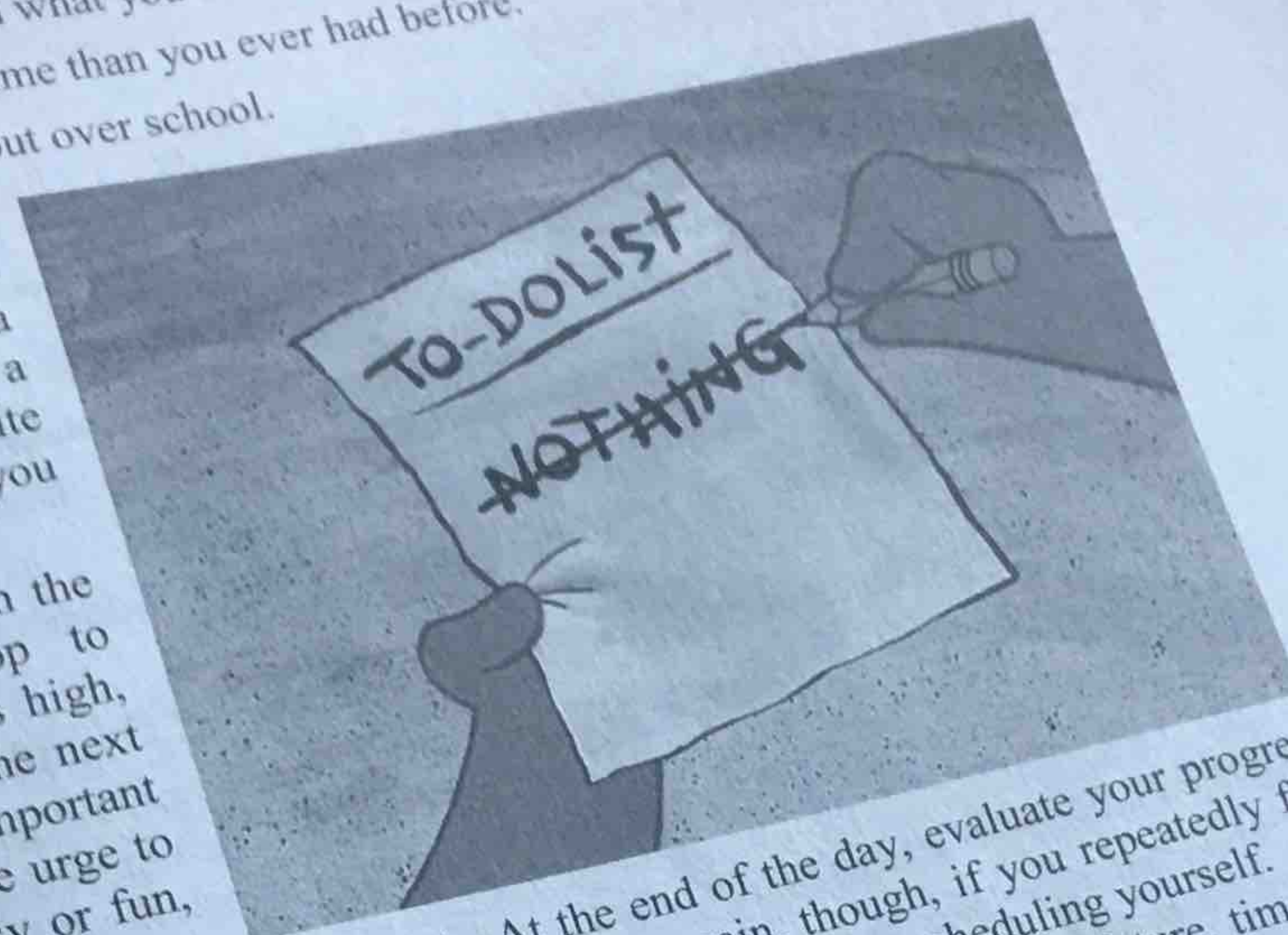
Predictable Outcome of Scheduling Your Time

If you are like most students, you will find that by scheduling your time and following the schedule, you will feel as though you have more time than you did before and your stress level will go down. Many students spend more time worrying about the fact that they are not studying than they do actually studying. "Tending to business" can give you a real sense of well-being.

In summary, the benefits of scheduling your study time are:

- You will be able to see immediately if you are overextended.
- You are more likely to keep up in your classes and to devote adequate time studying.
- You'll get immediate feedback as to how much you are actually studying.

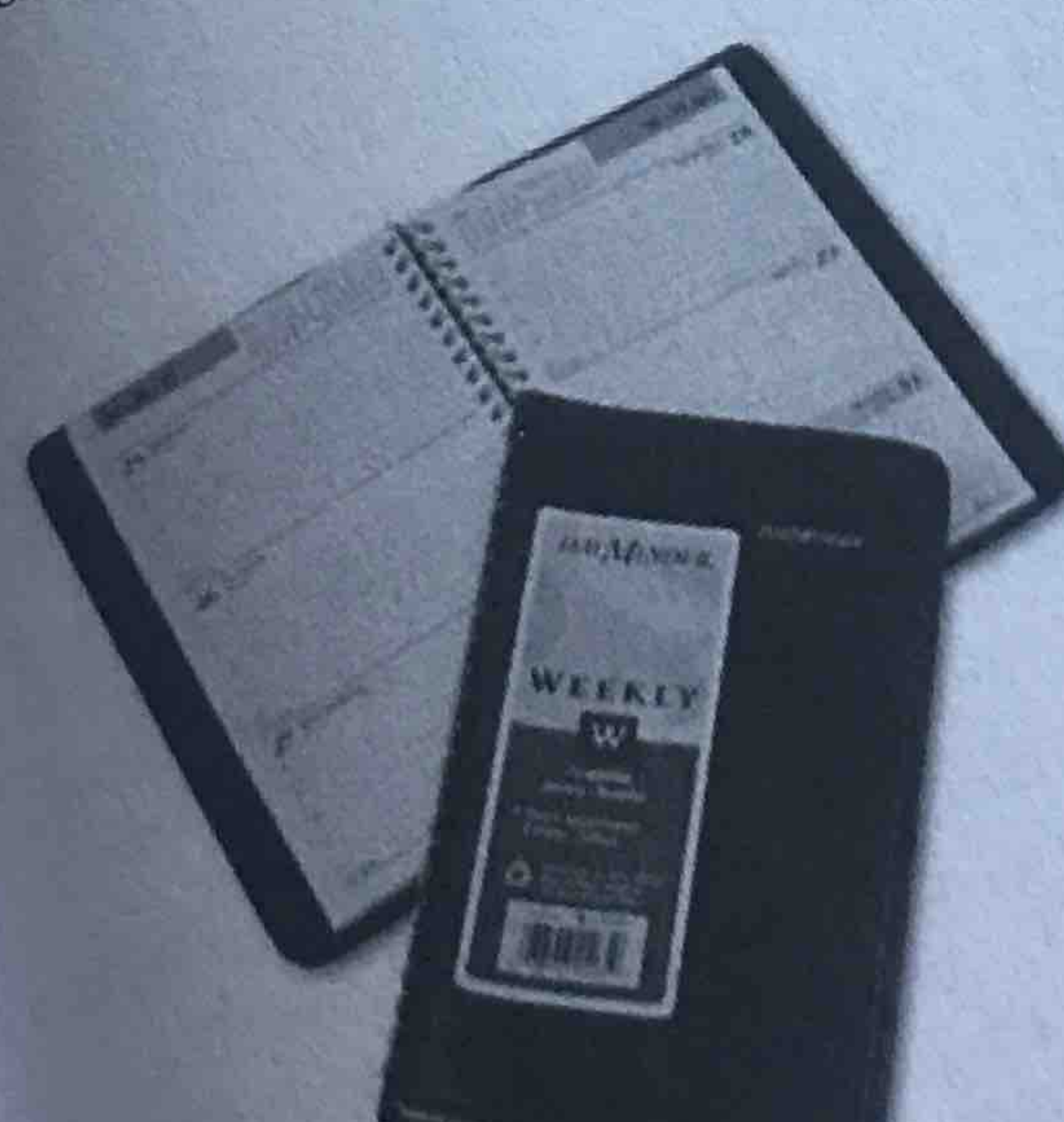
- You'll learn about yourself – both what you can and cannot do.
- You'll feel that you have more time than you ever had before.
- You'll feel much less stressed out over school.



DAILY PLANNING: "TO DO" LIST. One final approach to getting the most out of each day is to make up a daily "to do" list. To do this, take a few minutes each evening and write down a specific list of what you want to get done in the next day.

Then prioritize the items on the list, ranking them from top to bottom or classifying each as high, medium, or low priority. The next day, work on the most important items first. Try to avoid the urge to work on items that are easy or fun, but are of low priority. As you complete items, cross them off your "to do" list. At the end of the day, evaluate your progress and reschedule any items that remain on your list. Once again, though, if you repeatedly find that you can't accomplish everything on the list, you are probably over-scheduling yourself. And having to reschedule unaccomplished "to do" items means borrowing from the future, time that isn't there.

USING A LONG-TERM PLANNER. In addition to planning each week, you need a way to keep track of long-term commitments, important dates, and deadlines. Your campus bookstore or a local office supply store has both academic year planners and calendar year planners for this purpose.



Enter appointments, activities, events, tasks, and other commitments that extend beyond the current week in this planner. These might be academically-related, such as test dates, due dates for laboratory reports or term papers, meetings of student organizations, engineering seminars or guest speakers, and advising appointments. Also include personal appointments such as medical and dental checkups and car maintenance schedules; special occasions such as birthdays, anniversaries, and holidays; and recreational activities such as parties, concerts, plays, and the like.

Each week, as you make up your weekly schedule, transfer commitments from your long-term planner to your weekly schedule.

You may consider keeping your weekly schedules and long-term planners so that in the years to come you can enjoy them as a reminder of what you did during this uniquely important period of your life.

PRIORITY MANAGEMENT.

If you want to move to a higher level of managing your life, Stephen Covey points the way in his powerful book *Seven Habits of Highly Effective People* [5]. Covey's guiding principle is to:

> ***Organize and execute around priorities.***

Priority management means doing what needs to be done. There are two dimensions to deciding what needs to be done:

- How urgent is it? (Requires immediate attention or doesn't require immediate attention)
- How important is it based on your personal values? (Important; or not important)

These two dimensions – urgency and importance – are frequently confused. It's almost second nature to think that anything that's urgent must be important. The phone rings, we have to answer it. Our favorite TV show is on, we have to watch it. A friend wants to talk, we have to talk. Urgent matters press on us. They *demand* our attention. They're often popular to others. And often they are pleasant, easy, fun to do. But many urgent matters are not important!

"Importance" relates to whether it needs to be done at all. Not important should mean we don't do it at all. Much of our time and effort is devoted to tasks that are not important, whether they are urgent or not.

These dimensions can be shown visually by the following four quadrant matrix:

I **Urgent** **Important**	**II** **Not Urgent** **Important**
III **Urgent** **Not Important**	**IV** **Not Urgent** **Not Important**

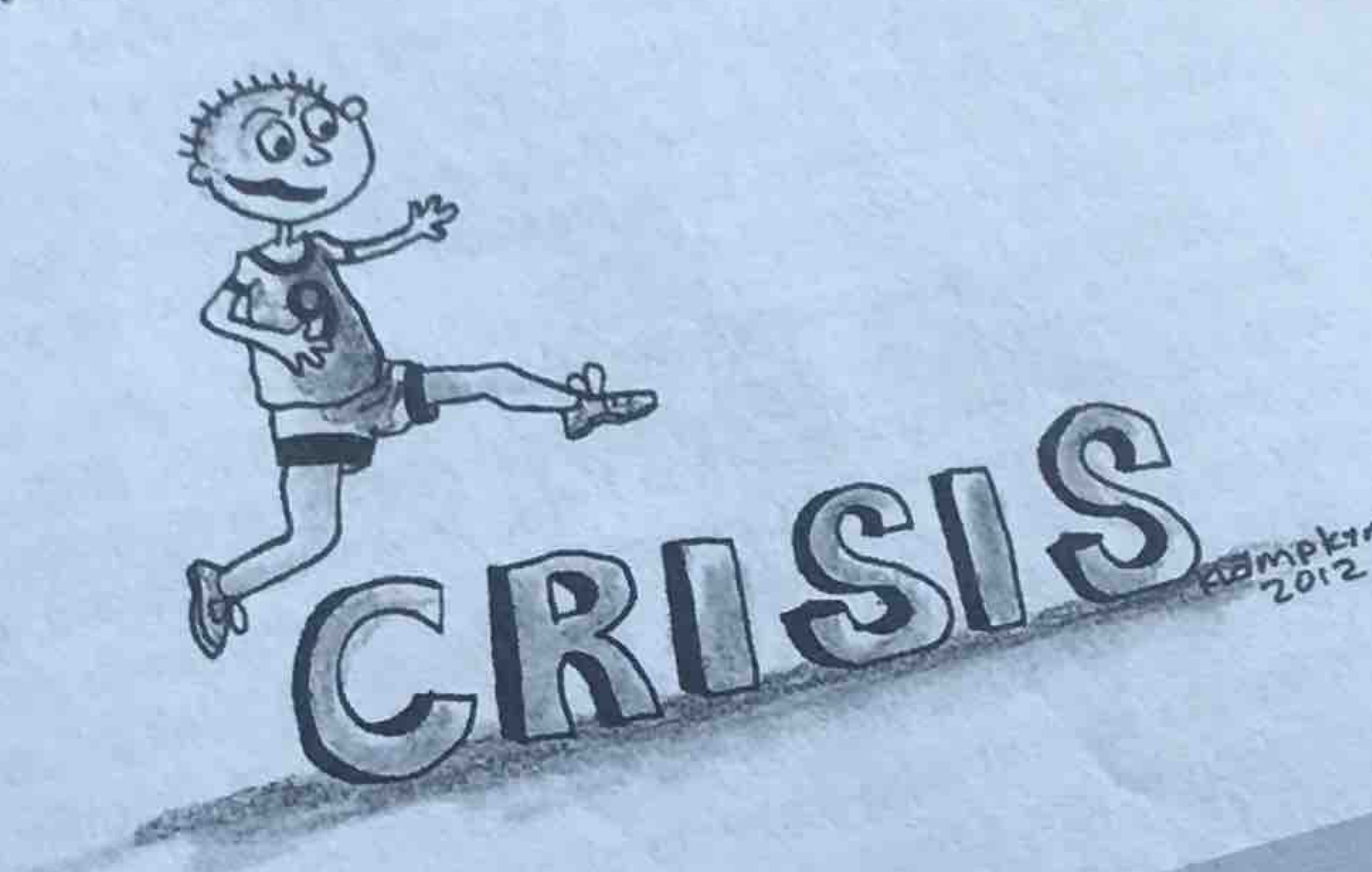
Key to the process of priority management is the criteria we use to determine what is important. This depends on our value system. Suffice it to say, candidates for high personal value include:

- School
- Family
- Friends
- Health
- Personal goals

Stay out of Quadrants III and IV. People who spend time almost exclusively in Quadrants III and IV lead basically irresponsible lives. Effective people stay out of Quadrants III and IV because, urgent or not, activities in these quadrants aren't important. You might have already guessed that staying out of Quadrant III will require you to become good at saying "no."

Activities in Quadrant I are what Covey describes as "crisis management" activities. Much of your life is dominated by activities that are both urgent and important. Time to go to class. Need to prepare for tomorrow's exam. Term paper due. Need to go to work. All important and urgent things.

We can't ignore the urgent and important activities of Quadrant I. However, our overall effectiveness will be controlled by Quadrant II – i.e., how we handle the things that are important but don't have to be done today. Since we can't skip Quadrant I activities, finding time for Quadrant II activities will require that we give up activities from Quadrants III and IV.



One bit of good news: In time, choosing Quadrant II activities will have the benefit of reducing the need to always operate from the crisis management perspective of Quadrant I.

REFLECTION

Reflect on the academic success strategies presented in the chapters indicated:

Structuring your life situation (Chapter 1)
Preparing for lectures (Chapter 4)
Seeking one-on-one instruction from your professors (Chapter 4)
Utilizing tutors and other academic resources (Chapter 4)
Scheduling your study time (Chapter 5)
Mastering the material presented in each class before the next class comes (Chapter 5)

Are these Quadrant I, II, III, or IV activities? Do they have to be done immediately or not? Are they important or not?

5.3 PREPARING FOR AND TAKING TESTS

As you learned in Chapter 1, a vital component of successful engineering study is becoming a *master* at preparing for and taking tests.

PREPARING FOR TESTS

Clearly, the best way to prepare for tests is to practice the many strategies discussed earlier. When I hear a student boast that he or she stayed up all night studying for a test, I know this is a student who is not doing well. This is substantiated by a recent study by researchers at the UCLA Semel Institute for Neuroscience and Human Behaviors [6] that concluded:

"Sacrificing sleep for extra study time is counterproductive."

You, too, should recognize this by now.

The student who brags about staying up all night to study most likely does not study from class to class, does not schedule his or her time well, does not understand the learning process (i.e., the need for incremental, reinforced learning), and does not realize the pitfalls of studying alone (The image of a student staying up all night studying for a test certainly fits the "lone wolf" metaphor, doesn't it?).

The truth is, if you have incorporated the study skills we have discussed into your regular study habits – even just the one skill of "taking it as it comes" – preparing for a test is not very hard. It merely involves adjusting your schedule several days prior to the test to review the material. You should never have to cover new material when preparing for a test.

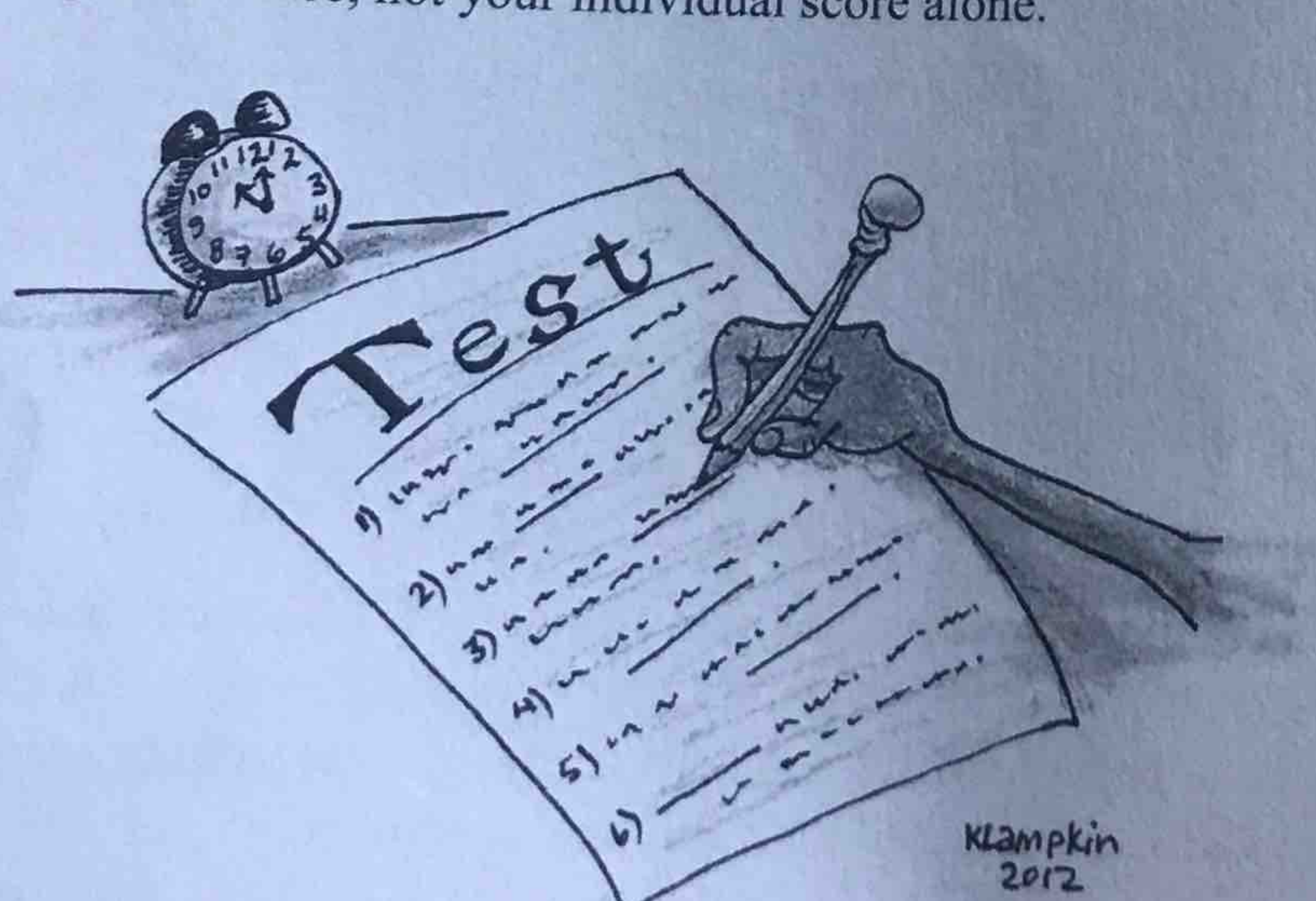
There is, however, one major aspect of test-taking that distinguishes it from all other forms of studying and learning: time pressure. That is, to do your best on tests, you need to learn how to work under the pressure of time.

Here are some useful tips that will improve your performance on tests and lessen your anxiety about taking them. Several days before a test, spend a portion of your study time working problems under a time limit. If you can, obtain tests from previous semesters or, better yet, construct your own. Creating and taking your own practice exams will give you invaluable experience in solving problems under pressure, plus it will give you the added advantage of learning to "scope out" tests. In time you will significantly improve your ability to work under pressure and to predict what will be on tests.

Unlike the student who stays up all night frantically cramming, be sure to get eight or nine hours of sleep before a test. Arrive at the test site early so you have ample time to gather your thoughts and be sure you have whatever materials you'll need: paper, pencils, allowed reference material, and acceptable computation tools. A certain amount of psyching yourself up, similar to what an athlete does prior to a big game, might be helpful; however, you don't want to get so nervous that you can't concentrate.

TEST-TAKING STRATEGIES

When you are given the test, don't start work immediately. Glance over the entire test first and quickly separate out the easier problems from the harder ones. Many instructors grade on a curve, which means that your grade will be based on its relation to the class's average performance, not your individual score alone.



If this is the case, you also need to size up the overall difficulty of the test and guess what the class average will be. In fact, jot down your estimate so that you can compare it later with the actual outcome. Through this process, over time you will become adept at sizing up tests. You will be able to recognize that on one test, it may take a score of 90 to get an "A," while on another test it may only require 50. Knowing that you only need to get a portion of the problems correct for a good grade will greatly affect the way you approach a test.

Once you have sized up the test, don't start with the first problem; start with the easiest one. As you work the easier problems and accumulate points, your confidence will build and you will develop a certain momentum.

But always keep an eye on the clock. If you divide the time available by the number of problems, you will know approximately how much time to spend on each.

Use this as a guide to pace yourself. Also, try to complete a problem before leaving it, and avoid jumping from one uncompleted problem to another, since you will waste time getting restarted on each.

Although you are under a time constraint, be sure to work carefully and attentively, as careless mistakes can be very costly. It is probably smarter to work three of five problems carefully than to do all five carelessly.

And by all means, never leave a test early. What do you have to do that could be more important than achieving the highest possible score on a test? If you have extra time, check and recheck your work. No matter how many times you proofread a term paper, mistakes can still be overlooked. The same is true for a test.

5.4 Making Effective Use of Your Peers

We close this chapter with one of the most important academic success strategies: making effective use of your peers. Your peers can significantly influence your academic performance, either positively or negatively.

Negative peer pressure put on those who apply themselves to learning is an age-old problem. Derisive terms like *dork*, *wimp*, *nerd*, *geek*, and *bookworm* are but a few of those used to exert social pressure on the serious student. You may have experienced this type of peer pressure in high school if your friends were not so serious about their academics as you, and you may have been forced into a pattern of studying alone – separating your academic life from your social life.

> ***As we discussed in Chapter 3, the "lone-wolf" approach to your academics may have worked for you in high school, but it is doubtful that it will work for you in engineering study, where the concepts are much more complex and the pace much faster.***

Even if you are able to make it through engineering study on your own, you will miss out on many of the benefits of collaborative learning and group study.

Overview of Collaborative Learning

In a previous section, we discussed teaching modes: large lectures, small lectures, recitations, and tutoring sessions. Now we turn to ***learning modes***. There are really only two:

(1) Solitary

(2) Collaborative

Either you try to learn by yourself or you do it with others.

As I travel the country, I always make an effort to visit *Introduction to Engineering* classes, where I ask students, "How many of you, when you study, spend some of that time with at least one other student?" Generally, in a class of 30 students, three or four hands will go up. Then I ask, "How many of you spend all of your time studying by yourself?" And the remaining 90 percent of hands go up.

> ***My anecdotal research indicates that about 90 percent of first-year engineering students do virtually 100 percent of their studying alone.***

Hence, the predominant learning mode in engineering involves a student working alone to master what are often difficult, complex concepts and principles and then apply them to solve equally difficult, complex problems.

The fact that most students study alone is indeed unfortunate because research shows that students who engage in collaborative learning and group study perform better academically, persist longer, improve their communication skills, feel better about their educational experience, and have enhanced self-esteem. We just read essentially the same message in that excerpt from the Harvard University study (See Chapter 3, Page 103). As even more evidence, Karl A. Smith, Civil Engineering professor at the University of Minnesota and a nationally recognized expert on cooperative learning, has found that [7]:

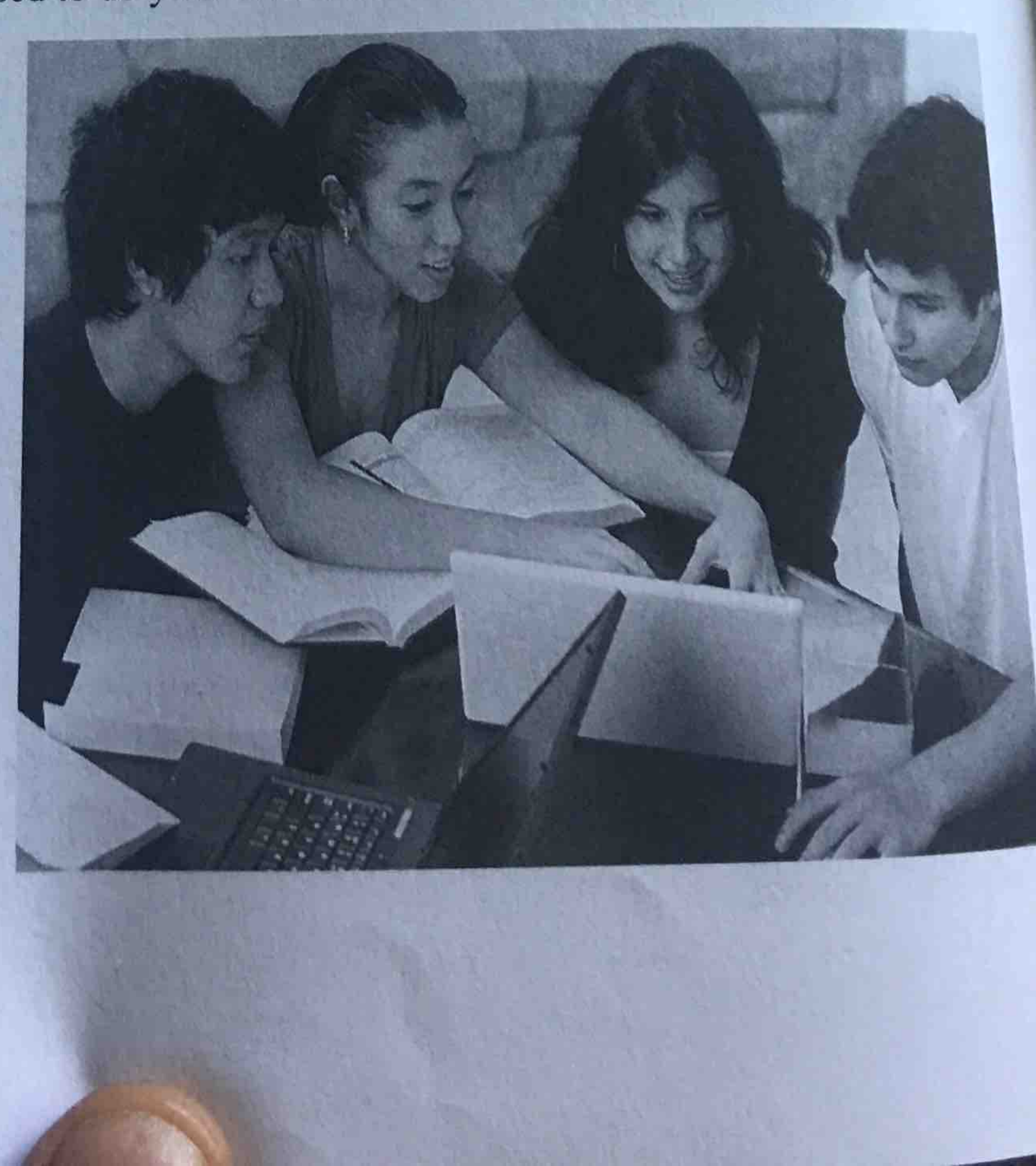
> **Cooperation among students typically results in:**
>
> **a. Higher achievement and greater productivity**
>
> **b. More caring, supportive, and committed relationships**
>
> **c. Greater psychological health, social competence, and self-esteem**

Over a period of many years, I have made a special effort to understand why most first-year engineering students study alone. Whenever I have the opportunity, I ask students, "Why don't you study with other students?" I almost always get one of these three answers:

(1) "I learn more studying by myself."

(2) "I don't have anyone to study with."

(3) "It's not right. You're supposed to do your own work."



The first of these reasons is simply wrong. It contradicts all the research that has been done on student success and learning. The second reason is really an excuse. Your classes are overflowing with other students who are working on the same homework assignments and preparing for the same tests as you are. The third reason is either a carryover from a former era when the culture of engineering education emphasized "competition" over "collaboration," or it comes from that romanticized ideal of the "rugged individualist" that we debunked in Chapter 3.

Today, the corporate buzzwords are "collaboration" and "teamwork" and engineering programs are under a strong mandate to turn out graduates who have the skills to work well in teams.

If you are using any of these reasons to justify your "lone-wolf" approach to academic work, you should now see their inherent problems and consider changing your approach.

Benefits of Group Study

If you're still not convinced, then look at the issue from a different perspective. Instead of focusing on the weaknesses or problems of solitary study, consider the strengths or benefits of group study. In this light, you will find three very powerful, persuasive reasons for choosing the collaborative approach over the solitary one:

(1) You'll be better prepared for the engineering work world.

(2) You'll learn more.

(3) You'll enjoy it more.

Each of these is discussed in the following sections.

You'll Be Better Prepared for the Engineering Work World. Whether you choose to study alone or with others often depends on what you think is the purpose of an engineering education. If you think the purpose of that education is to develop your proficiency at sitting alone mastering knowledge and applying that knowledge to solving problems, then that's what you should do. However, I doubt you will find anyone who will hire you to do that. It's not what practicing engineers do by and large.

So if you spend your four or five years of engineering study sitting alone mastering knowledge and applying that knowledge to the solution of problems (and perhaps becoming very good at it), you will have missed out on much of what a quality engineering education should entail.

A quality education trains you not only to learn and to apply what you learn, but also to communicate what you know to others, explain your ideas to others, listen to others explain their ideas to you, and engage in dialogues and discussions on problem formulations and solutions. You may come up with a very important "breakthrough" idea, but if you can't convince others of it, it is unlikely that your idea will be adopted.

You'll Learn More. Do you recall our earlier discussion of traditional teaching modes, all of which keep learning to a minimum? In essence, group study and collaborative learning pick up where those modes leave off – and the result is an increase in what you learn.

There are a number of ways to explain how this happens. One is the adage that "*two minds are better than one.*" Through collaborative study, not only will more information be brought to bear, but you will have the opportunity to see others' thought processes at work. Perhaps you have played the game *Trivial Pursuit*. It always amazes me how a small group of people working together can come up with the answer to a question that no member of the group working alone could have done.

Another explanation comes from the claim that:

> ***If you really want to learn a subject, teach it.***

It's true! As an undergraduate engineering student, I took three courses in thermodynamics. Yet I didn't really understand the subject until I first taught it. When two students work together

collaboratively, in effect, half the time one student is teaching the other and half the time the roles are reversed.

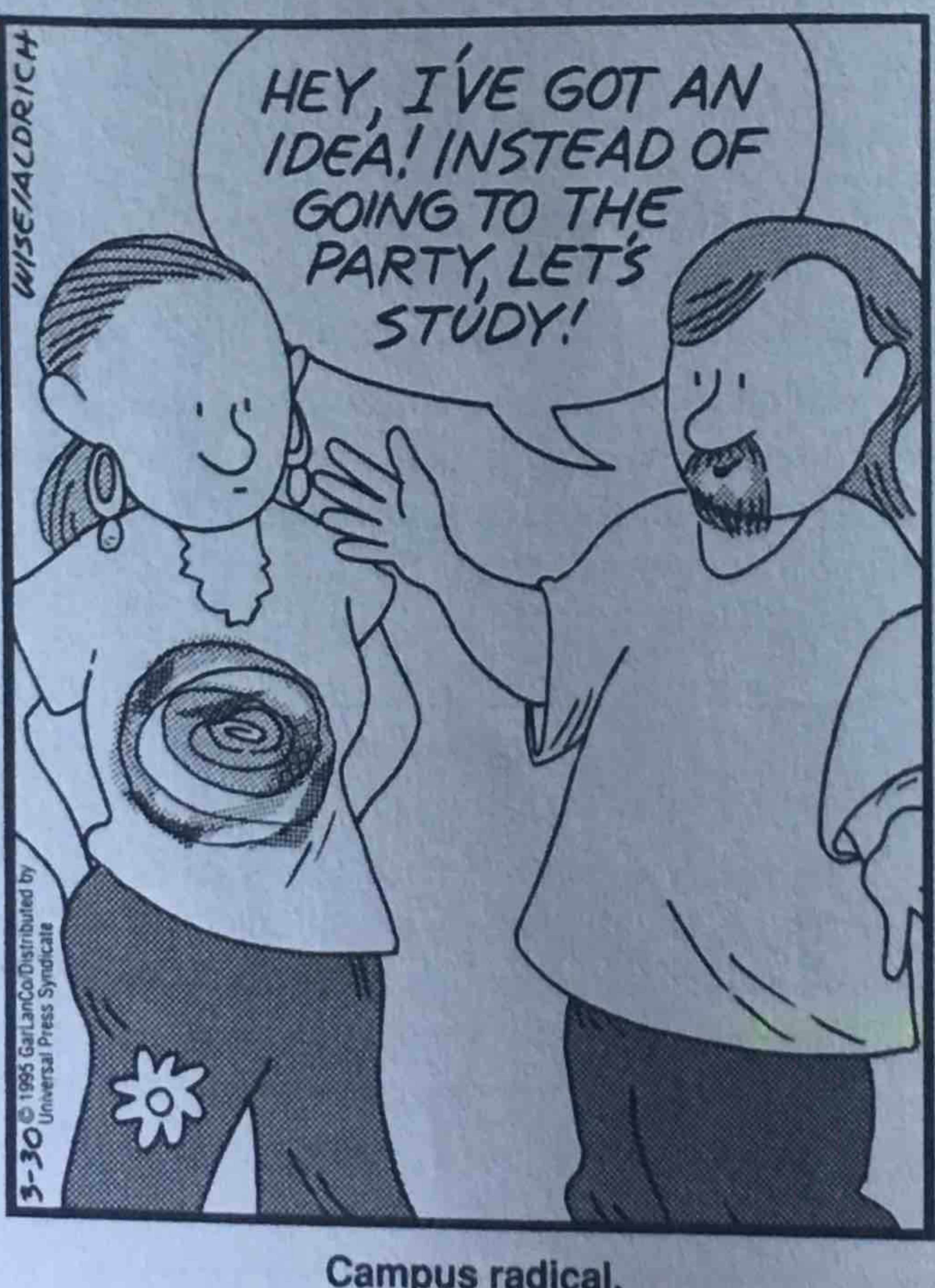
<u>YOU'LL ENJOY IT MORE.</u> Group study is more fun and more stimulating than solitary study, and because you'll enjoy it more, you are likely to do more of it. This wonderful benefit of group study can be illustrated by the following personal story.

My Own Experience with Group Study

When I was working on my Ph.D., a close friend of mine and I took most of our courses together. To prepare for exams, we typically would meet early on a Saturday morning in an empty classroom and take turns at the board deriving results, discussing concepts, and working problems. Before we knew it, eight or ten hours would have passed.

There is no way I would have spent that amount of time studying alone on a Saturday at home. Would you? The temptations of TV, the Internet, phones, email, and friends, along with the need to run errands or do work around the house, would surely have prevailed over my planned study time. By integrating my academic work with my social needs, I enjoyed studying more and did more of it.

The true value of academic relationships is illustrated in the following cartoon:



Campus radical.

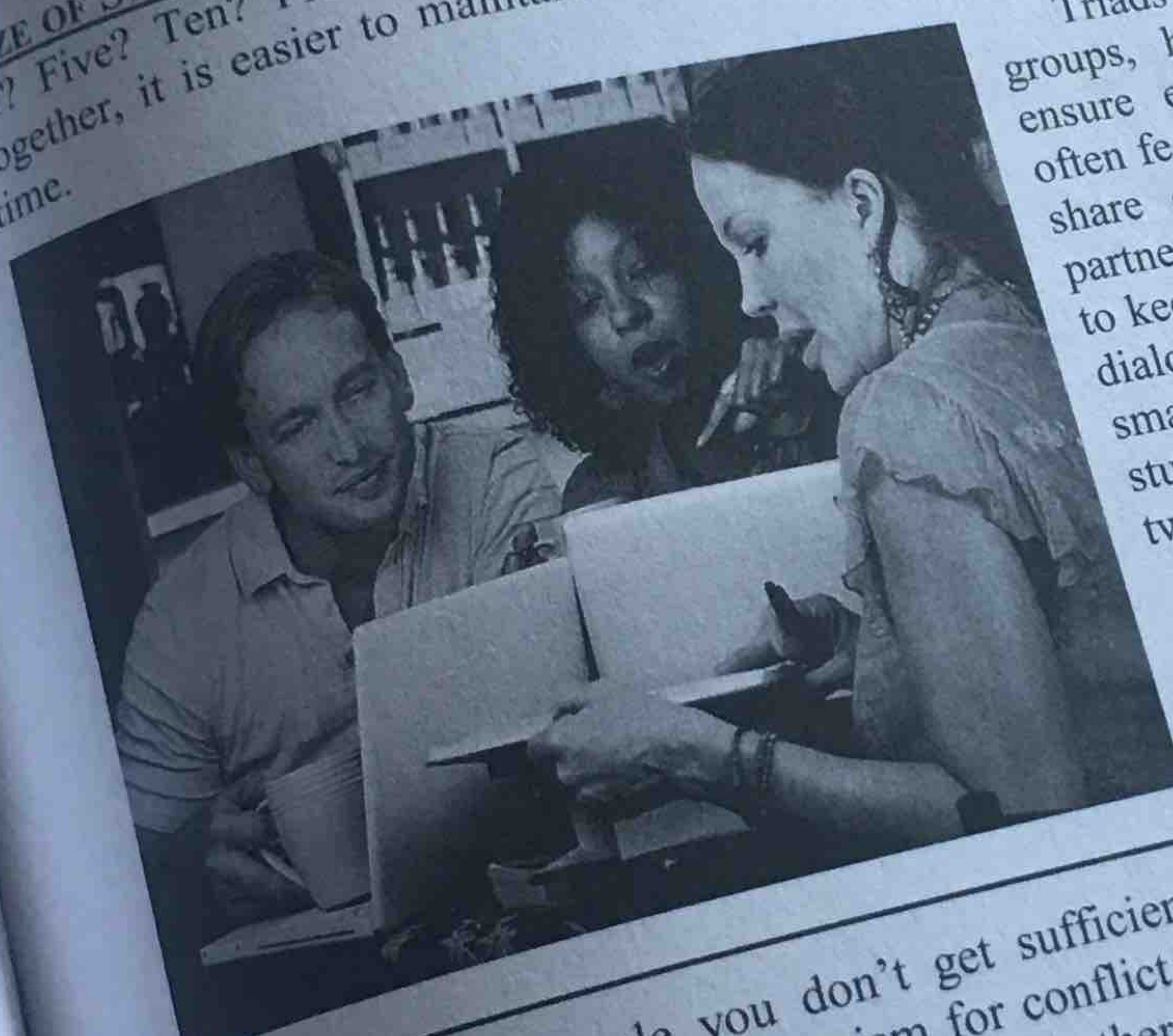
FREQUENTLY ASKED QUESTIONS ABOUT COLLABORATIVE LEARNING

- What percentage of my studying should be done in groups?
- What is the ideal size of a study group?
- What can be done to keep the group from getting off task?

Although there are no definitive answers to these questions, the following points serve as reliable guidelines.

PERCENTAGE OF TIME. Certainly, you should not spend all of your study time working collaboratively. I would suggest somewhere between 25 and 50 percent. Prior to coming together, each member of a group should study the material and work as many problems as possible to gain a base level of proficiency. The purpose of the group work should be to reinforce and deepen that base level of understanding. The better prepared group members are when they come together, the more they can accomplish during their study sessions.

SIZE OF STUDY GROUP. When you hear the term "study group," what size group do you think of? Five? Ten? Fifteen? My ideal size is ***two***. Think study "partners." When two people work together, it is easier to maintain a balanced dialogue, where each is the "teacher" for half the time.



Triads can work well too. In larger groups, however, it can be difficult to ensure equal participation and members often feel the need to compete for their fair share of the time. Even between study partners, a conscious effort may be required to keep one of the two from dominating the dialogue. My advice is to keep the groups small. If more people come together to study, it's okay. Generally, subgroups of twos or threes will develop.

While I think two is the ideal size of a study group, Richard Felder of North Carolina State University sent me the following different view:

> "With two people you don't get sufficient diversity of ideas and approaches, and there's no built-in mechanism for conflict resolution, so the dominant member of the pair will win most of the debates, whether he/she is right or wrong. Five is too many – someone will usually get left out. I suggest three as the ideal size, with four in second place, and two in third."

I would encourage you to experiment to see what works best for you.

STAYING ON TASK. You may find it difficult to stay on task when working with others. There are no simple solutions to this problem, for it really boils down to students' discipline and commitment to their education. Once again, though, size may be a factor: The larger the group, the more difficult it will be to keep everyone focused on academics. Yet even in groups of two or three, staying on task can be a problem.

I have found it helpful to split up a group's meeting time into a series of short study sessions with breaks between sessions. Agree, for example, to study for 50 minutes and then take a ten-minute break. After the break, it's back to work for another 50 minutes, followed by another ten-minute break. And so on.

If nothing else seems to help your group to stay on task, then you're left with only one solution: *Just do it.*

REFLECTION

Do you spend some fraction of your study time on a regular basis with at least one other student? Or do you spend virtually 100 percent of your study time alone? If you don't study with other students, why not? Did the ideas presented in this section persuade you of the value of group study and collaborative learning? Are you willing to try it out? Make a commitment to identify a study partner in one of your key classes and schedule a two-hour study session with that person.

It Really Works

I often conduct workshops on collaborative learning, and at some point I have half of the class work on a problem in small groups and the other half work by themselves on the same problem. After about ten minutes, the ones who are working alone start looking at their watches and appear restless and bored. When time is called after 45 minutes, those who are working in groups are disappointed and ask for more time. They often express that they are just getting "hot" on a solution to the problem.

The next day I ask, "How many of you continued thinking about, working on, or talking to others about the problem we did yesterday?" Most of those who worked in groups raise their hands, whereas those who worked alone do not.

NEW PARADIGM

Collaboration and *cooperation* represent a major new paradigm in business and industry, replacing that of *competition* which began with the Industrial Revolution and held sway well into the twentieth century.

Collaborative learning is consistent with modern engineering management practice and with what industry representatives tell us they want in our engineering graduates. *Competition* and *individual achievement* are outdated notions, and rightly so. W. Edwards Deming, father of the Total Quality Management (TQM) movement to use statistical methods to improve product quality, makes a compelling case [8]:

"We have grown up in a climate of competition between people, teams, departments, divisions, pupils, schools, universities. We have been taught by economists that competition will solve our problems. Actually, competition, we see now, is destructive. It would be better if everyone would work together as a system, with the aim for everybody to win. What we need is cooperation and transformation to a new style of management . . . Competition leads to loss. People pulling in opposite directions on a rope only exhaust themselves. They go nowhere. What we need is cooperation. Every example of cooperation is one of benefit and gains to them that cooperate. Cooperation is especially productive in a system well managed."

I hope you will seek opportunities for cooperation and collaboration with your fellow students, and that in doing so you will reap much greater rewards than you would have through competition and individual effort.

Conclusion

On a concluding note, I want to stress that implementing the success strategies presented in this chapter requires you to change – change how you think about things (your attitudes) and change how you go about these things (your behaviors). Thus, the value of any of the strategies mentioned above – indeed, the value of this entire book – depends on the extent to which you can make such changes. To help you succeed in what can be a difficult process, in Chapter 6 you will learn about the psychology of change, along with ways to gain insights into yourself, and a detailed process for your personal growth and development will be presented.

SUMMARY

This chapter addressed the important topic of "Making the Learning Process Work for You." Effective learning involves many skills and, as in developing any skill, practice makes perfect.

We began the chapter by discussing two very important learning skills: reading for comprehension and analytical problem solving. Your success in engineering study will depend in large part on your skill in these two areas.

We then described the process of organizing your learning process. We emphasized perhaps the most important academic success strategy in the chapter, if not in the entire book – the need to keep up in your classes by mastering the material presented in each class before the next class comes. Approaches for mastering material, along with important time and priority management skills, were also presented.

Next we discussed strategies for preparing for and taking tests. This subject deserves particular attention since most of your grade in math/science/engineering coursework will be based on your performance on tests and exams.

The chapter concluded with approaches for making effective use of one of the most important resources available to you – your fellow students. By working collaboratively with your peers, particularly in informal study groups, sharing information with them and developing habits of mutual support, you will learn more and enjoy your education more. At the same time, you will become well-prepared for the engineering work world, where teamwork and cooperation are highly valued.

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PROBLEMS

1. Prepare a ten-minute talk on the methodology presented in Section 5.1 on *Reading for Comprehension*. Persuade a classmate from one of your other classes (not your *Introduction to Engineering* course) to listen to your talk and give you feedback on how well you understand and communicate the concepts.

2. Make a commitment to follow the steps in the methodology presented on *Reading for Comprehension* in Section 5.1 for one week. Be particularly attentive to the three "Before You Read" steps and to the recitation step "After You Read." Write a one-page paper on how the methodology impacted your learning.

3. Solve this problem following each of the four steps for analytical problem solving presented in Section 5.1. Use the problem-solving strategies of *solving a simpler problem* and *drawing a diagram*.

   A painter built a ladder using 18 rungs. The rungs on the ladder were 5.7 inches apart and 1.1 inches thick. What is the distance from the bottom of the lowest rung to the top of the highest rung?

4. Solve this problem following each of the four steps for analytical problem solving presented in Section 5.1 using the *guess and check* strategy. Using the *make a table* strategy. Using the *solve an equation* strategy.

   Amanda has 26 nickels and dimes in her piggy bank. The number of nickels is two fewer than three times the number of dimes. How much money does she have in her piggy bank?

5. Using the form presented at the end of this chapter, schedule your study time for one week. Attempt to follow the schedule. Write a one-page paper describing what happened.

6. Make a "To Do" list of things you need to do. Place each item in one of the four quadrants of Covey's matrix shown on Page 148. How many items are in Quadrant I? How many are in Quadrant II? How many are in Quadrant III and IV?

7. Go to your campus library and find a book on study skills. Check out the book and scan its "Table of Contents." Identify one interesting section and read it thoroughly. Then write an essay on why you picked the topic you did and what you learned about it.

8. If you studied for 100 hours, how many of those hours would be spent studying alone and how many would be spent studying with at least one other student?

9. If your answer to Problem 8 was that you spend most of your time studying alone, seek out a study partner in one of your math/science/engineering classes. Get together for a study session. Write down what worked well and what didn't work well.

10. Interview two junior or senior engineering majors and ask the following questions:
    a. What was the main difference they found between high school and university-level engineering study?
    b. What were the most important study skills they had to learn?
    c. What approach do they use to manage their time effectively?
    d. What do they think about group study?

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
8-9							
9-10							
10-11							
11-12							
12-1							
1-2							
2-3							
3-4							
4-5							
5-6							
6-7							
7-8							
8-9							
9-10							