Introduction

PART 1: HOW YOU CAN USE THIS BOOK

QUICKSTART

If you never read the material at the front of your books anyway, and if you’re in a hurry to begin and only want to read one paragraph, here it is:

Most chapters in this book are independent. Start with any one and look through it. Use the index extensively. Decide if you are going to work problems in that topic. If so, solve as many problems in that topic as time allows. Don’t stop studying until the exam. Start right now! Quickly! Good luck.

However, if you want to begin a thorough review, you should probably try to find out everything there is to know about the PE exam. The rest of this introduction is for you.

IF YOU ARE A PRACTICING ENGINEER

If you are a practicing engineer and have obtained this book as a general reference handbook, it will probably sit in your bookcase until you have a specific need. However, if you are preparing for the PE examination in mechanical engineering, the following suggestions may help.

- Find out the current edition of this book. You might be reading this book long after it was published. Newer editions mean that older editions are no longer appropriate for the current exam. Newer editions mean that the codes, standards, and regulations on which the exam is based are not represented in the older edition, that the exam body of knowledge has changed, and/or the exam format and policies have changed. New editions are published for a reason, and it’s not reasonable for you to expect the older edition to serve your needs when it is out of date.

- Be reasonable in what you expect from this book. Much like any textbook, this book is a compilation of material designed to help you learn certain subjects—in this case, subjects on the exam. This book does not contain “everything” that you need to know to pass the exam, particularly the afternoon parts of the exam. You will need to assemble a library of other references. This book is not a substitute for the experience, general knowledge, and judgment that engineers are expected to demonstrate on the exam. This book will help you learn subjects. It won’t help you pass the exam if you go into the exam unprepared or unqualified.

- Become intimately familiar with this book. This means knowing the order of the chapters, the approximate locations of important figures and tables, what appendices are available, and so on.

- Use the subject title tabs along the side of each page. The tab names correspond to the exam organization.

- Use Table 1 and Table 2 of this Introduction to learn which subjects in this book are (and are not) specific exam subjects. Some chapters in this book are supportive and do not cover specific exam topics. However, these chapters provide background and support for the other chapters.

- Some engineers read every page in a chapter. Some merely skim through a chapter and its appendices. In either case, you must familiarize yourself with the subjects before starting to solve practice problems.

- Identify and obtain a set of 10–30 solved practice problems for each of the exam subjects. I have written an accompanying book, Practice Problems for the Mechanical Engineering PE Exam, for this purpose. Other resources include the Mechanical Engineering Practice Examination, books in the Six-Minute series, and the Mechanical PE Exam Cafe, all offered by PPI. You may use problem sets from your old textbooks, college notes, or review course if they are more convenient. Regardless of the books you use, you should know that you will encounter two types of practice problems. Some problems look like examination problems. They are short and have multiple-choice answers. This type of problem is good for familiarizing yourself with the exam format. However, it is not very effective for exposing you to the integration of multiple concepts in problem solving, for familiarizing you with this book, and for making sure you have seen all of the “gotchas” that are possible in a subject. To address those requirements, you’ll need some longer problems. Practice Problems for the Mechanical Engineering PE Exam contains both types of problems.
• Most of the problems in Practice Problems for the Mechanical Engineering PE Exam are presented in both customary U.S. (English) and SI units. Initially, work through the problems in U.S. units. If you have time at the end of your review, start over and solve all of the problems in SI units.

• Set a reasonable limit on the time you spend on each subject. It isn’t necessary to solve an infinite number of practice problems. The number of practice problems you attempt will depend on how much time you have and how skilled you are in the subject.

• If it isn’t already your habit, practice carrying units along in all calculations. Many errors are caused by, and many incorrect exam answer options are based on, common mistakes with units. Pounds don’t work in \( \frac{F}{m} \) nor in \( \frac{ft^2}{sec} \). When working in customary U.S. (English) units, you will find equations in this book in which the quantity \( g/f_g \) appears. For calculations at standard gravity, the numerical value of this fraction is 1.00. Therefore, it is necessary to incorporate this quantity only in calculations with a nonstandard gravity or when you are being meticulous with units.

• Use the solutions to your practice problems to check your work. If your answer isn’t correct, figure out why.

• To minimize time spent in searching for often-used formulas and data, prepare a one-page summary of all the important formulas and information in each subject area. You can then use these summaries during the examination instead of searching in this book. You can develop your own, or you may want to consider Quick Reference for the Mechanical Engineering PE Exam, which PPI has published for this type of use.

• Use the index extensively. Every significant term, law, theorem, and concept has been indexed in every conceivable way—backward and forward—using fuzzy logic synonyms in anticipation of frantic exam searches. If you don’t recognize a term used, look for it in the index. Many engineers bring a separate copy of the index with them to the exam.

• Some subjects appear in more than one chapter. Use the index liberally to learn all there is to know about a particular subject.

IF YOU ARE AN INSTRUCTOR

The first two editions of this book consisted of a series of handouts prepared for the benefit of my PE review courses. These editions were intended to be compilations of all the long formulas, illustrations, and tables of data that I did not have time to put on the chalkboard. You can use this edition in the same way.

If you are teaching a review course for the PE examination, you can use the material in this book as a guide to prepare your lectures. To make your preparation even easier, PPI has developed the Mechanical PE Exam Review Course Manual, which is available for download at www.ppi2pass.com/MERC. The Review Course Manual is organized into lessons that are derived from the chapters in this book. Each lesson includes instructor notes, lesson plans, and visual aids. Additional example and practice problems are also included and may be assigned as homework. Each Review Course Manual lesson focuses on aspects of mechanical engineering that are most important for the mechanical PE exam, with an understanding that you are lecturing only two or three hours. If you have more time, you can augment Review Course Manual material with more material from this book.

I have always tried to overprepare my students. For that reason, the homework problems (i.e., example problems in this book and the practice problems in the companion Practice Problems for the Mechanical Engineering PE Exam book) are often more difficult and more varied than actual examination questions. Also, you will appreciate the fact that it is more efficient to cover several procedural steps in one problem than to ask simple “one-liners” or definition questions. That is the reason that the example and homework problems are often harder and longer than actual exam problems.

To do all the homework for some chapters requires approximately 15 to 20 hours. If you are covering one or more chapters per week, that’s a lot of homework per week. “Capacity assignment” is the goal in my review courses. If you assign 20 hours of homework and a student is able to put in only 10 hours that week, that student will have worked to his or her capacity. After the PE examination, that student will honestly say that he or she could not have prepared any more than he or she did in your course. For that reason, you have to assign homework on the basis of what is required to become proficient in the subjects of your lecture. You must resist assigning only the homework that you think can be completed in an arbitrary number of hours.

Homework assignments in my review courses are not individually graded. Instead, students are permitted to make use of existing solutions to learn procedures and techniques to the problems in their homework set, such as those in the companion Practice Problems for the Mechanical Engineering PE Exam book, which contains solutions to all practice problems. However, each student must turn in a completed set of problems for credit each week. Though I don’t correct the homework problems, I address comments or questions emailed to me, posted on the course forum, or written on the assignments.

I believe that students should start preparing for the PE exam at least six months before the examination date. However, most wait until three or four months before getting serious. Because of that, I have found that a 13- or 14-week format works well for a live PE review course. It’s a little rushed, but the course is over before everyone gets bored with my jokes. Each week, there is a
three-hour meeting, which includes lecture and a short break. Table 1 outlines a course format that might work for you. If you can add more course time, your students will appreciate it. Another lecture covering heat transfer, HVAC, or machine design would be wonderful. However, I don’t think you can cover the full breadth of material in much less time or in many fewer weeks.

I have tried to order the subjects in a logical, progressive manner, keeping my eye on “playing the high-probability subjects.” For example, heat transfer and HVAC are dependent on thermodynamics principles, so they come after the thermodynamics chapters. Also, machine design comes after statics, engineering materials, and strengths of materials.

Lecture coverage of some examination subjects is necessarily brief; other subjects are not covered at all. These omissions are intentional; they are not the result of scheduling omissions. Why? First, time is not on our side in a review course. Second, some subjects rarely contribute to the examination. Third, some subjects are not well-received by the students. For example, I have found that very few people study modeling and systems analysis, material handling, and manufacturing methods. Unless you have six months in which to teach your PE review, your students’ time can be better spent covering other subjects.

All the skipped chapters and any related practice problems are presented as floating assignments to be made up in the students’ “free time.”

I strongly believe in exposing my students to a realistic sample examination, but I no longer administer an in-class mock exam. Since the review course usually ends only a few days before the real PE examination, I hesitate to make students sit for several hours in the late evening to take a “final exam.” Rather, I distribute and assign a take-home sample exam at the first meeting of the review course.

If the practice test is to be used as an indication of preparedness, caution your students not to even look at the sample exam prior to taking it. Looking at the sample examination, or otherwise using it to direct their review, will produce unwarranted specialization in subjects contained in the sample examination.

There are many ways to organize a PE review course, depending on your available time, budget, intended audience, facilities, and enthusiasm. However, all good course formats have the same result: The students struggle with the workload during the course, and then they breeze through the examination after the course.

### PART 2: EVERYTHING YOU EVER WANTED TO KNOW ABOUT THE PE EXAM

#### WHAT IS THE FORMAT OF THE PE EXAM?

The NCEES PE examination in mechanical engineering consists of two four-hour sessions separated by a one-hour lunch period. The morning “breadth” (a.m.) session is taken by all examinees. There are three afternoon “depth” (p.m.) modules: HVAC and refrigeration, mechanical systems and materials (formerly known as “machine design”), and thermal and fluids systems. (The depth modules may be referred to as “discipline-specific,” or DS, modules, borrowing a term from the FE exam.) You must be approved by your state licensing board before you can register for the exam using the “My NCEES” system on the NCEES website. You select your depth module when you register for the exam.

At the exam, you will receive an examination booklet for the depth module you selected during registration. Switching modules is not possible. Your answer sheet will be scored based on the module you selected during registration.

Both the morning and afternoon sessions contain 40 questions in multiple-choice (i.e., “objective”) format. As this is a “no-choice” exam, you must answer all questions in each session correctly to receive full credit. There are no optional questions.

<table>
<thead>
<tr>
<th>meeting</th>
<th>subject covered</th>
<th>chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to the Exam, Units, Mathematics</td>
<td>1, 3–12</td>
</tr>
<tr>
<td>2</td>
<td>Thermodynamics</td>
<td>22–24</td>
</tr>
<tr>
<td>3</td>
<td>Power Cycles</td>
<td>26–33</td>
</tr>
<tr>
<td>4</td>
<td>Compressible Fluid Flow</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Heat Transfer</td>
<td>34–37</td>
</tr>
<tr>
<td>6</td>
<td>Fluids and Hydraulic Machines</td>
<td>14–19</td>
</tr>
<tr>
<td>7</td>
<td>Fans, Ductwork, and Terminal Devices</td>
<td>41</td>
</tr>
<tr>
<td>8</td>
<td>HVAC</td>
<td>38–44</td>
</tr>
<tr>
<td>9</td>
<td>Combustion</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>Engineering Materials and Statics</td>
<td>45–49</td>
</tr>
<tr>
<td>11</td>
<td>Mechanics of Materials</td>
<td>50–52</td>
</tr>
<tr>
<td>12</td>
<td>Mechanical Systems and Machine Design</td>
<td>53–56</td>
</tr>
<tr>
<td>13</td>
<td>Kinematics of Machinery</td>
<td>57–61</td>
</tr>
<tr>
<td>14</td>
<td>Engineering Economic Analysis</td>
<td>74</td>
</tr>
</tbody>
</table>

Table 1 Typical PE Exam Review Course Format
WHAT SUBJECTS ARE ON THE PE EXAM?

NCEES has published a description of subjects on the examination. Irrespective of the published examination structure, the exact number of questions that will appear in each subject area cannot be predicted reliably.

There is no guarantee that any single subject will occur in any quantity. One of the reasons for this is that some of the questions span several disciplines. You might categorize and solve a steam flow question as a fluids dynamics (ideal gas or compressible flow) problem, while NCEES might categorize it as a thermodynamics problem.

Table 2 describes the subjects in detail. Most examinees find the list to be formidable in appearance. The percentage breakdowns in Table 2 are according to NCEES, but these percentages are approximate. NCEES adds,

‘...that will apply to (typically) two to five following questions. Such grouped questions are increasingly rare, however. Each of the questions will have four answer options, labeled “A,” “B,” “C,” and “D.” If the answer options are numerical, they will be displayed in increasing value. One of the answer options is correct (or, will be “most nearly correct,” as described in the following section). The remaining answer options are incorrect and may consist of one or more “logical distractors,” the term used by NCEES to designate incorrect options that look nearly correct.

NCEES intends the questions to be unrelated. Questions are independent or start with new given data. A mistake on one of the questions shouldn’t cause you to get a subsequent question wrong. However, considerable time may be required to repeat previous calculations with a new set of given data.

HOW MUCH “LOOK-UP” IS REQUIRED ON THE EXAM?

Since the questions are multiple choice in design, all required data will appear in the situation statement.

Since the examination would be unfair if it was possible to arrive at an incorrect answer after making valid assumptions or using plausible data, you will not generally be required to come up with numerical data that might affect your success on the problem. Friction factors and pipe roughness, thermal conductivities, U- and R- heat transfer factors, most pipe sizes, material strengths and other properties, and relevant assumptions will be given in the question statement. There will also be superfluous information in the majority of questions.

WHAT DOES “MOST NEARLY” REALLY MEAN?

One of the more disquieting aspects of these questions is that the available answer choices are seldom exact. Answer choices generally have only two or three significant digits. Exam questions ask, “Which answer choice is most nearly the correct value?” or they instruct you to complete the sentence, “The value is approximately...” A lot of self-confidence is required to move on to the next question when you don’t find an exact match for the answer you calculated, or if you have had to split the difference because no available answer choice is close.

NCEES describes it like this:

Many of the questions on NCEES exams require calculations to arrive at a numerical answer. Depending on the method of calculation used, it is very possible that examinees working correctly will arrive at a range of answers. The phrase “most nearly” is used to accommodate answers that have been derived correctly but that may be slightly different from the correct answer choice given on the exam. You should use good engineering judgment when selecting your choice of answer. For example, if the question asks you to calculate an electrical current or determine the load on a beam, you should literally select the answer option that is most nearly what you calculated, regardless of whether it is more or less than your calculated value. However, if the question asks you to select a fuse or circuit breaker to protect against a calculated current or to size a beam to carry a load, you should select an answer option that will safely carry the current or load. Typically, this requires selecting a value that is closest to but larger than the current or load.

The difference is significant. Suppose you were asked to calculate “most nearly” the volumetric pure airflow required to dilute a contaminated air stream to an
Table 2 Detailed Analysis of Tested Subjects

MORNING SESSION
(40 multiple-choice questions)

Basic Engineering Practice (30%)
Engineering terms and symbols; economic analysis; project management; interpretation of technical drawings; electrical concepts; units and conversions

Mechanical Systems and Materials (20%)
Principles (15%): statics and dynamics; strength of materials; stress analysis; fatigue theory
Applications (7%): mechanical components (e.g., springs, gears, pressure vessels); joints and fasteners (e.g., welding, bolts, adhesives); vibration and dynamic analysis; materials selection (e.g., corrosion, weight, strength)

Hydraulics and Fluids (17%)
Principles (7%): compressible and incompressible flow
Applications (10%): hydraulic and fluid equipment (e.g., pumps, turbines, compressors); piping systems and components

Energy/Power Systems (15%)
Principles (7%): thermodynamic cycles and properties; energy and mass balances; heat transfer; combustion
Applications (8%): power conversion systems; energy/power equipment (e.g., turbines, boilers, engines); heat exchangers

HVAC/Refrigeration (18%)
Principles (10%): psychrometrics; refrigeration systems; heat transfer
Applications (8%): HVAC and refrigeration systems and components (e.g., air handlers, compressors); heating and cooling loads

AFTERNOON SESSIONS
(40 multiple-choice questions per exam)

HVAC AND REFRIGERATION DEPTH EXAM

Principles (55%)
Thermodynamics (7%): cycles; properties; compression processes
Psychrometrics (15%): heating and cooling cycles; humidification and dehumidification; heating and cooling loads
Heat Transfer (13%)
Fluid Mechanics (7%)
Compressible Flow (3%)
Energy Balances (10%)
Applications (45%)
Equipment and components (20%): cooling towers and fluid coolers; boilers and furnaces; condensers; pumps, compressors, and fans; evaporators and chillers; cooling and heating coils; control systems components; refrigerants; refrigeration components
Systems (18%): air distribution; fluid distribution; refrigeration; energy recovery
Supportive knowledge (7%): codes and standards; air quality and ventilation; vibration control; acoustics; economic analysis; electrical concepts

MECHANICAL SYSTEMS AND MATERIALS DEPTH EXAM

Principles (60%)
Statics (15%): free body diagrams; friction; centroids; inertia
Kinematics (7%): linear and rotational motion; velocity; acceleration
Dynamics (10%): particle and rigid body
Materials properties (10%): physical; chemical; mechanical
Strength of materials (18%): stress and strain; shear; bending; buckling; torsion
Applications (40%)
Mechanical components (10%): pressure vessels; bearings; gears; springs; belts, pulleys, and chains; clutches and brakes; power screws; shafts and keys; mechanisms; mechatronics
Joints and fasteners (10%): welding and brazing; bolts, screws, and rivets; adhesives and soldering; others (e.g., pipe threads, snap rings, interference fit)
Vibration/dynamic analysis (10%): natural frequencies; damping; forced vibrations; vibration isolation; dynamic analysis
Materials and process (10%): materials selection; manufacturing processes; fits and tolerances; economic analysis and project management; quality control

(continued)
Table 2 Detailed Analysis of Tested Subjects\textsuperscript{a,b} (continued)

THERMAL AND FLUIDS SYSTEMS DEPTH EXAM

Principles (45%)
- Materials properties (5%): density; viscosity
- Fluid mechanics (10%): compressible and incompressible fluids
- Heat transfer principles (10%): convection; conduction; radiation
- Mass balance principles (7%): evaporation; dehumidification; combustion
- Thermodynamics (10%): thermodynamic cycles and properties; energy balances; combustion
- Related principles (3%): strength of materials; fatigue theory; statics and dynamics; stress analysis; psychrometrics; welding; safety; quality control and assurance

Applications (55%)
- Equipment (18%): pumps; turbines; compressors, fans, and blowers; boilers and steam generators; engines and drive trains; pressure vessels; heat exchangers, condensers, and feedwater heaters; cooling towers; control devices
- Systems (32%): power hydraulics; pneumatic power; fluid distribution; power conversion; energy recovery; cooling and heating cycles; power cycles
- Codes and standards (5%)

\textsuperscript{a}Considerable overlap, duplication, and flexibility exists in each topic.
\textsuperscript{b}NCEES may occasionally revise exam subjects somewhat. For the most current information, visit the Exam FAQs section of PPI’s website, www.ppi2pass.com/mefaq.

acceptable concentration. Suppose, also, that you calculated the answer to be 823 cfm. If the answer choices were (A) 600 cfm, (B) 800 cfm, (C) 1000 cfm, and (D) 1200 cfm, you would go with answer choice (B), because it is most nearly what you calculated. If, however, you were asked to select a fan or duct with the same rated capacities, you would have to go with choice (C), because an 800 cfm fan wouldn’t be sufficient. Got it?

HOW MUCH MATHEMATICS IS NEEDED FOR THE EXAM?

There are no pure mathematics questions (algebra, geometry, trigonometry, etc.) on the exam. However, you will need to apply your knowledge of these subjects to the exam questions.

Generally, only simple algebra, trigonometry, and geometry are needed on the PE exam. You will need to use the trigonometric, logarithm, square root, exponentiation, and similar buttons on your calculator. There is no need to use any other method for these functions.

Except for simple quadratic equations, you will probably not need to find the roots of polynomial equations. For second-order (quadratic) equations, the exam does not care if you find roots by factoring, completing the square, using the quadratic equation, graphing, or using your calculator’s root finder. Occasionally, it will be convenient to use the equation-solving capability of your calculator. However, other solution methods will always exist.

There is essentially no need to solve differential equations. Questions involving radioactive decay, seismic vibrations, control systems, chemical reactions, and fluid mixing have appeared from time to time. However, these applications are extremely rare, have usually been first-order, and could usually be handled without having to solve differential equations.

Basic statistical analysis of observed data may be necessary. Statistical calculations are generally limited to finding means, medians, standard deviations, variances, percentiles, and confidence limits. Since the problems are multiple choice, you won’t have to draw a histogram, although you might have to interpret one. Usually, the only population distribution you need to be familiar with is the normal curve. Probability, reliability, hypothesis testing, and statistical quality control are not explicit exam subjects, though their concepts may appear peripherally in some problems. You will not have to use linear or nonlinear regression and other curve fitting techniques to correlate data.

Quantitative optimization methods, such as linear, dynamic, and integer programming, generally associated with the field of operations research are not exam subjects.

The PE exam is concerned with numerical answers, not with proofs or derivations. You will not be asked to prove or derive formulas, use deductive reasoning, or validate theorems, corollaries, or lemmas.

Inasmuch as first assumptions can significantly affect the rate of convergence, problems requiring trial-and-error solutions are unlikely. Rarely, a calculation may require an iterative solution method. Generally, there is no need to complete more than two iterations. You will not need to program your calculator to obtain an “exact” answer. Nor will you generally need to use complex numerical methods.
HOW ABOUT ENGINEERING ECONOMICS?

For most of the early years of engineering licensing, questions on engineering economics appeared frequently on the examinations. This is no longer the case. However, in its outline of exam subjects, NCEES notes: “Some questions may require knowledge of engineering economics.” What this means is that engineering economics concepts might appear in several questions on the exam, or the subject might be totally absent. While the degree of engineering economics knowledge has decreased somewhat, the basic economic concepts (e.g., time value of money, present worth, non-annual compounding, comparison of alternatives, etc.) are still valid test subjects.

If engineering economics is incorporated into other questions, its “disguise” may be totally transparent. For example, you might need to compare the economics of buying and operating two blowers for remediation of a hydrocarbon spill—blowers whose annual costs must be calculated from airflow rates and heads. Also, you may need to use engineering economics concepts and tables in problems that don’t even mention “dollars” (e.g., when you need to predict future water demand, population, or traffic volume).

WHAT ABOUT FIRE PROTECTION ENGINEERING?

At one time, fire protection was a topic on the mechanical engineering PE exam. Numerical questions dealt with sprinkler capacity, sprinkler layout, fire pumps, hydrants, standpipes, hose and nozzle flow rate, and occupancy categories. This topic disappeared when the mechanical engineering PE exam adopted the breadth-and-depth format. However, piping, pumps, valve, and controls for fire protection are easily categorized into other exam topics. The fire protection chapter in this book covers basic material that might still be useful on the exam.

WHAT ABOUT NUCLEAR ENGINEERING?

At one time, nuclear engineering problems appeared regularly on the mechanical engineering PE exam. These problems dealt with shielding, health safety, core power development, decay, liquid metal flow and heat transfer, and core design. Such problems disappeared when the nuclear engineering PE exam became available. Problems involving nuclear reactor environments continue to appear, but these can always be solved with “traditional” heat transfer, thermodynamic, power cycle, and fluid machinery concepts.

WHAT ABOUT PROFESSIONALISM AND ETHICS?

For many decades, NCEES has considered adding professionalism and ethics questions to the PE exam. However, these subjects are not part of the test outline, and there has yet to be an ethics question in the exam. Professional practice questions dealing with obligations related to contracts, bidding, estimating, inspection, and regulations sometimes get pretty close. However, you won’t encounter the phrase “ethical obligation” in the exam.

WHAT ABOUT CODES AND STANDARDS?

NCEES lists “codes and standards” in its lists of exam topics without identifying any specific codes and standards. For that reason, at least for the mechanical engineering PE exam, “codes and standards” seems to imply “knowledge about codes and standards,” opposed to “possession of and reference to the codes and standards” during the exam. The distinction is significant, because (without a specific list) it would be unreasonably expensive to purchase every code and standard affecting mechanical engineers. Among others, ASME, ASTM, ANSI, ASHRAE, SAE, NFPA, NEC, AGMA, EPA, OSHA, and other U.S. organizations publish numerous documents, as do Canada and the European Union (EU).

There are a few noteworthy exceptions: ASME Y14.5 (Dimensioning and Tolerancing); ASME Boiler and Pressure Vessel Code (BPVC) Sec. VIII, Div. 1; ASHRAE Standard 62.1 (Ventilation for Acceptable Indoor Air Quality); TEMA’s Standards of the Tubular Exchanger Manufacturers Association; and, OSHA CFR 29. Depending on your afternoon discipline, one or more of these publications could be valuable.

Inasmuch as fire protection is no longer a specific topic on the mechanical PE exam, none of the NFPA publications should be needed. A useful standard for non-fatigue applications, ASME’s Code for Design of Transmission Shafting (ASA-B17c), is obsolete and is unlikely to be needed during the exam.

IS THE EXAM TRICKY?

Other than providing superfluous data, the PE exam is not a “tricky exam.” The exam does not overtly try to get you to fail. Examinees manage to fail on a regular basis with perfectly straightforward questions. The exam questions are difficult in their own right. NCEES does not need to provide misleading or conflicting statements. However, you will find that commonly made mistakes are represented in the available answer choices. Thus, the alternative answers (known as distractors) will be logical.

Questions are generally practical, dealing with common and plausible situations that you might experience in your job. You will not be asked to determine the radiated heat transfer from the side of a spacecraft at night after it has landed on a Jovian moon with a methane atmosphere.
DOES NCEES WRITE EXAM QUESTIONS AROUND THIS BOOK?

Only NCEES knows what NCEES uses to write its exam questions. However, it is irrelevant, because this book is not intended to (1) be everything you need to pass the exam, (2) expose exam secrets or exam questions, or (3) help you pass when you don’t qualify to pass. NCEES knows about this book, but worrying about NCEES writing exam questions based on information that is or is not in this book means you are placing too much dependency on this book. This book, for example, will teach you how to use aspects of many standards and codes. Expecting that this book will replace those standards and codes is unrealistic. This book will provide instruction in certain principles. Expecting that you will not need to learn anything else is unrealistic. This book presents many facts, definitions, and numerical values. Expecting that you will not need to know other facts, definitions, and numerical values is unrealistic. What NCEES uses to write exam questions won’t have any effect on what you need to do to prepare for the exam.

WHAT MAKES THE QUESTIONS DIFFICULT?

Some questions are difficult because the pertinent theory is not obvious. There may be only one acceptable procedure, and it may be heuristic (or defined by a code) such that nothing else will be acceptable. For example, if you don’t know the AGMA procedure for designing gears, no other knowledge of gear design is going to be helpful for an AGMA question.

Some questions are difficult because the data needed are hard to find. Some data just aren’t available unless you happen to have brought the right reference book. Solving some HVAC problems depends on having climatological data for a specific location and performance characteristics of specific construction types.

Some questions are difficult because they defy the imagination. Problems involving epicyclical gear trains can be like this. If you cannot visualize the operation of the mechanism . . . if you cannot get an intuitive feeling about what is going on, you probably cannot analyze it.

Some questions are difficult because the computational burden is high, and they just take a long time. Convective heat transfer, HVAC, and pipe networks analyzed with the Hardy-Cross method fall into this category.

Some questions are difficult because the terminology is obscure, and you just don’t know what the terms mean. This can happen in almost any subject.

DOES THE PE EXAM USE SI UNITS?

The PE exam in mechanical engineering primarily uses customary U.S. units (also known as “English units,” “inch-pound units,” and “British units”), although SI and a variety of other metric systems are also used. Questions use the units that correspond to commonly accepted industry standards. Metric units are used in chemical-related subjects, including electrical power (watts) and water concentration (mg/L) questions. Either system can be used for fluids, stress analysis, and thermodynamics, although the use of metric units is still rare.

Unlike this book, the exam does not differentiate between lbf and lbm (pounds-force and pounds-mass). Similarly, the exam does not follow this book’s practice of meticulously separating the concepts of mass and weight, density and specific weight, and gravity, \( g \), and the gravitational constant, \( gc \).

WHY DOES NCEES REUSE SOME QUESTIONS?

NCEES reuses some of the more reliable questions from each exam. The percentage of repeat questions isn’t high—no more than 25% of the exam. NCEES repeats questions in order to equate the performance of one group of examinees with the performance of an earlier group. The repeated questions are known as equaters, and together, they are known as the equating subtest.

Occasionally, a new question appears on the exam that very few of the examinees do well on. Usually, the reason for this is that the subject is too obscure or the question is too difficult. Questions on control systems and some engineering management subjects (e.g., linear programming) fall into this category. Also, there have been cases where a low percentage of the examinees get the answer correct because the question was inadvertently stated in a poor or confusing manner. Questions that everyone gets correct are also considered defective.

NCEES tracks the usage and “success” of each of the exam questions. “Rogue” questions are not repeated without modification. This is one of the reasons historical analysis of question types shouldn’t be used as the basis of your review.

DOES NCEES USE THE EXAM TO PRE-TEST FUTURE QUESTIONS?

NCEES does not use the PE exam to “pre-test” or qualify future questions. (It does use this procedure on the FE exam, however.) All of the questions you work will contribute toward your final score.

ARE THE EXAMPLE PROBLEMS IN THIS BOOK REPRESENTATIVE OF THE EXAM?

The example problems in this book are intended to be instructional and informative. They were written to illustrate how their respective concepts can be implemented. Example problems are not intended to represent exam problems or provide guidance on what you should study.
ARE THE PRACTICE PROBLEMS REPRESENTATIVE OF THE EXAM?

The practice problems in the companion Practice Problems for the Mechanical Engineering PE Exam book were chosen to cover the most likely exam subjects. Some of the practice problems are multiple choice, and some require free-format solutions. However, they are generally more comprehensive and complex than actual exam problems, regardless of their formats.

Practice problems in the companion book were selected to complement subjects in the Mechanical Engineering Reference Manual. Over the many editions of both books, the practice problems have developed into a comprehensive review of the most important mechanical engineering subjects covered on the exam.

All of the practice problems are original. Since NCEES does not release old exams, and since examinees are sworn to secrecy before taking the exam, none of the practice problems are actual exam problems.

WHAT REFERENCE MATERIAL IS PERMITTED IN THE EXAM?

The PE examination is an open-book exam. Most states do not have any limits on the numbers and types of books you can use. Personal notes in a three-ring binder and other semipermanent covers can usually be used.

Some states use a “shake test” to eliminate loose papers from binders. Make sure that nothing escapes from your binders when they are inverted and shaken.

The references you bring into the examination room in the morning do not have to be the same as the references you use in the afternoon. However, you cannot share books with other examinees during the exam.

A few states do not permit collections of solved problems such as Schaum’s Outline Series, sample exams, and solutions manuals. A few states maintain a formal list of banned books.

Strictly speaking, loose paper and scratch pads are not permitted in the examination. Certain types of pre-printed graphs and logarithmically scaled graph papers (which are almost never needed) should be three-hole punched and brought in a three-ring binder. An exception to this restriction may be made for laminated and oversize charts, graphs, and tables (e.g., Mollier diagrams and psychrometric charts) that are commonly needed for particular types of questions. However, there aren’t many such items for the mechanical PE exam.

HOW MANY BOOKS SHOULD YOU BRING?

Except for codes and standards, you shouldn’t need many books in the examination, particularly in the morning breadth section. The trouble is, you can’t know in advance which ones you will need. That’s the reason why many examinees show up with boxes and boxes of books. Since this book is not a substitute for your own experience and knowledge, without a doubt, there are many things that you will need that are not in this book. But there are not so many that you need to bring your entire company’s library. The examination is very fast-paced. You will not have time to use books with which you are not thoroughly familiar. The exam doesn’t require you to know obscure solution methods or to use difficult-to-find data. You won’t need articles printed in an industry magazine; you won’t need doctoral theses or industry proceedings; and, you won’t need to know about recent industry events.

So, it really is unnecessary to bring a large quantity of books with you. Essential books are identified in Table 3 in this Introduction, and you should be able to decide which support you need for the areas in which you intend to work. This book and five to ten other references of your choice should be sufficient for most of the questions you answer.¹

MAY TABS BE PLACED ON PAGES?

It is common to tab pages in your books in an effort to reduce the time required to locate useful sections. Inasmuch as some states consider Post-it® notes to be “loose paper,” your tabs should be of the more permanent variety. Although you can purchase tabs with gummed attachment points, it is also possible simply to use transparent tape to securely attach the Post-its you have already placed in your books.

MAY YOU WRITE AND MARK IN YOUR BOOKS?

During your preparation, you may write anything you want, anywhere in your books, including this one. You can use pencil, pen, or highlighter in order to further your understanding of the content. However, during the exam, you must avoid the appearance of taking notes about the exam. This means that you should only write on the scratch paper that is provided. During the exam, other than drawing a line across a wide table of numbers, or using your pencil to follow a line on a graph, you should not write in your books.

WHAT ABOUT CALCULATORS?

The exam requires use of a scientific calculator. However, it may not be obvious that you should bring a spare calculator with you to the examination. It is always unfortunate when an examinee is not able to finish because his or her calculator was dropped or stolen or stopped working for some unknown reason.

¹For decades, this introduction has recommended that you bring an engineering/scientific dictionary with you, but this recommendation is no longer valid. Printed engineering/scientific dictionaries appear to be things of the past. Those that still exist are not very good, and none are targeted enough to be helpful with the modern afternoon depth examinations.
To protect the integrity of its exams, NCEES has banned communicating and text-editing calculators from the exam site. NCEES provides a list of calculator models acceptable for use during the exam. Calculators not included in the list are not permitted. Check the current list of permissible devices at the PPI website (www.ppi2pass.com/calculators). Contact your state board to determine if nomographs and specialty slide rules are permitted.

The exam has not been optimized for any particular brand or type of calculator. In fact, for most calculations, a $15 scientific calculator will produce results as satisfactory as those from a $200 calculator. There are definite benefits to having built-in statistical functions, graphing, unit-conversion, and equation-solving capabilities. However, these benefits are not so great as to give anyone an unfair advantage.

It is essential that a calculator used for the mechanical PE examination have the following functions.

- trigonometric and inverse trigonometric functions
- hyperbolic and inverse hyperbolic functions
- $\pi$
- $\sqrt{x}$ and $x^2$
- both common and natural logarithms
- $y^x$ and $e^x$

For maximum speed and utility, your calculator should also have or be programmed for the following functions.

- interpolation
- extracting roots of quadratic and higher-order equations
- calculating factors for economic analysis questions

You may not share calculators with other examinees. Be sure to take your calculator with you whenever you leave the examination room for any length of time.

Laptop, palmtop, and tablet computers (including the iPad®), and electronic readers (e.g., Nook® and Kindle®), are not permitted in the examination. Their use has been considered, but no states actually permit them. However, considering the nature of the exam questions, it is very unlikely that these devices would provide any advantage.

**ARE CELL PHONES PERMITTED?**

You may not possess or use a walkie-talkie, cell phone, or other communications or text-messaging device during the exam, regardless of whether it is on. You won’t be frisked upon entrance to the exam, but should a proctor discover that you are in possession of a communication device, you should expect to be politely excluded from the remainder of the examination.

**HOW YOU SHOULD GUESS**

There is no deduction for incorrect answers, so guessing is encouraged. However, since NCEES produces defendable licensing exams, there is no pattern to the placement of correct responses. Since the quantitative responses are sequenced according to increasing values, the placement of a correct answer among other numerical distractions is a function of the distractors, not of some statistical normalizing routine. Therefore, it is irrelevant whether you choose all “A,” “B,” “C,” or “D” when you get into guessing mode during the last minute or two of the exam period.

The proper way to guess is as an engineer. You should use your knowledge of the subject to eliminate illogical answer choices. Illogical answer choices are those that violate good engineering principles, that are outside normal operating ranges, or that require extraordinary assumptions. Of course, this requires you to have some basic understanding of the subject in the first place.

Otherwise, it’s back to random guessing. That’s the reason that the minimum passing score is higher than 25%.

You won’t get any points using the "test-taking skills" that helped you in college—the skills that helped with tests prepared by amateurs. You won’t be able to eliminate any [verb] answer choices from “Which [noun] . . .” questions. You won’t find problems with options of the “more than 50” and “less than 50” variety. You won’t find one answer choice among the four that has a different number of significant digits, or has a verb in a different tense, or has some singular/plural discrepancy with the stem. The distractors will always match the stem, and they will be logical.

**HOW IS THE EXAM GRADED AND SCORED?**

The maximum number of points you can earn on the mechanical engineering PE exam is 80. The minimum number of points for passing (referred to by NCEES as the cut score) varies from exam to exam. The cut score is determined through a rational procedure, without the benefit of knowing examinees’ performance on the exam. That is, the exam is not graded on a curve. The cut score is selected based on what you are expected to know, not based on passing a certain percentage of engineers.

Each of the questions is worth one point. Grading is straightforward, since a computer grades your score sheet. Either you get the question right or you don’t. If you mark two or more answers for the same problem, no credit is given for the problem.

You will receive the results of your examination from your state board (not NCEES) by mail. Eight to ten weeks will pass before NCEES releases the results to the state boards. However, the state boards take varying amounts of additional time before notifying examinees. You should allow three to four months for notification.
HOW IS THE CUT SCORE ESTABLISHED?

The cut score is established by NCEES before or after the exam is administered. Final adjustments may be made following the exam date.

NCEES uses a process known as the modified Angoff procedure to establish the cut score. This procedure starts with a small group (the cut score panel) of professional engineers and educators selected by NCEES. Each instructor in the group reviews each problem and makes an estimate of its difficulty. Specifically, each individual estimates the number of minimally qualified engineers out of a hundred examinees who should know the correct answer to the problem. (This is equivalent to predicting the percentage of minimally qualified engineers who will answer correctly.)

Next, the panel assembles, and the estimates for each problem are openly compared and discussed. Eventually, a consensus value is obtained for each. When the panel has established a consensus value for every problem, the values are summed and divided by 100 to establish the cut score.

Various minor adjustments can be made to account for examinee population (as characterized by the average performance on any other questions) and any flawed problems. Rarely, security breaches result in compromised problems or examinations. How equated questions, examination flaws, and security issues affect examinee performance is not released by NCEES to the public.

ARE ALL OF THE DEPTH MODULES EQUAL IN DIFFICULTY?

Nothing in the modified Angoff procedure ensures that the cut score will be the same in all of the depth modules. Thus, each depth module may have a different cut score. The easier the questions, the higher the cut score will be. Accordingly, the cut scores and passing rates are different for each depth module.

WHAT IS THE HISTORICAL PASSING RATE?

Before the mechanical engineering PE exam became a no-choice, breadth-and-depth (B&D) exam with multiple-choice questions, the passing rate for first-timers varied considerably. It might have been 40% for one exam and 80% for the next. The passing rate for repeat examinees was even lower. The no-choice, objective, B&D format has reduced the variability in the passing rate considerably. Within a few percentage points, 65–70% of first-time takers pass the mechanical engineering PE exam. The passing rate for repeat exam takers is approximately half of the first-time taker passing rate.

CHEATING AND EXAM SUBVERSION

There aren’t very many ways to cheat on an open-book test. The proctors are well trained in spotting the few ways that do exist. It goes without saying that you should not talk to other examinees in the room, nor should you pass notes back and forth. You should not write anything into your books or take notes on the contents of the exam. You shouldn’t use your cell phone. The number of people who are released to use the restroom may be limited to prevent discussions.

NCEES regularly reuses good problems that have appeared on previous exams. Therefore, examination integrity is a serious issue with NCEES, which goes to great lengths to make sure nobody copies the questions. You may not keep your exam booklet or scratch paper, enter text of questions into your calculator, or copy problems into your own material.

NCEES has become increasingly unforgiving about loss of its intellectual property. NCEES routinely prosecutes violators and seeks financial redress for loss of its examination problems, as well as invalidating any engineering license you may have earned by taking one of its examinations while engaging in prohibited activities. Your state board may impose additional restrictions on your right to retake any examination if you are convicted of such activities. In addition to tracking down the sources of any examination problem compilations that it becomes aware of, NCEES is also aggressive in pursuing and prosecuting examinees who disclose the contents of the exam in internet forums and “chat” environments.

Your constitutional rights to free speech and expression will not protect you from civil prosecution for violating the nondisclosure agreement that NCEES requires you to sign before taking the examination. If you wish to participate in a dialog about a particular exam subject, you must do so in such a manner that does not violate the essence of your nondisclosure agreement. This requires decoupling your discussion from the examination and reframing the question to avoid any examination particulars.

The proctors are concerned about exam subversion, which generally means activity that might invalidate the examination or the examination process. The most common form of exam subversion involves trying to copy exam problems for future use. However, in their zeal to enforce and protect, proctors have shown unforgiving intolerance of otherwise minor infractions such as using your own pencil, using a calculator not on the approved list, possessing a cell phone, or continuing to write for even an instant after “pencils...
down” is called. For such infractions, you should expect to have the results of your examination invalidated, and all of your pleas and arguments in favor or forgiveness to be ignored. Even worse, since you will summarily be considered to have cheated, your state board will most likely prohibit you from retaking the exam for a number of examination cycles. There is no mercy built into the NCEES and state board procedures.

**PART 3: HOW TO PREPARE FOR AND PASS THE PE EXAM IN MECHANICAL ENGINEERING**

**WHAT SHOULD YOU STUDY?**

The exam covers many diverse subjects. Strictly speaking, you don’t have to study every subject on the exam in order to pass. However, the more subjects you study, the more you’ll improve your chances of passing. You should decide early in the preparation process which subjects you are going to study. The strategy you select will depend on your background. Following are the four most common strategies.

A broad approach is the key to success for examinees who have recently completed their academic studies. This strategy is to review the fundamentals in a broad range of undergraduate subjects (which means studying all or most of the chapters in this book). The examination includes enough fundamentals problems to make this strategy worthwhile. Overall, it’s the best approach.

Engineers who have little time for preparation tend to concentrate on the subject areas in which they hope to find the most problems. By studying the list of examination subjects, some have been able to focus on those subjects that will give them the highest probability of finding enough problems that they can answer. This strategy works as long as the examination cooperates and has enough of the types of questions they need. Too often, though, examinees who pick and choose subjects to review can’t find enough problems to complete the exam.

Engineers who have been away from classroom work for a long time tend to concentrate on the subjects in which they have had extensive experience, in the hope that the exam will feature lots of problems in those subjects. This method is seldom successful.

Some engineers plan on modeling their solutions from similar problems they have found in textbooks, collections of solutions, and old exams. These engineers often spend a lot of time compiling and indexing the example and sample problem types in all of their books. This is not a legitimate preparation method, and it is almost never successful.

**DO YOU NEED A CLASSROOM REVIEW COURSE?**

Approximately 60% of first-time PE examinees take an instructor-led review course of some form. Live classroom and internet courses, as well as previously recorded lessons of various types, are available for some or all of the exam topics. Live courses and instructor-moderated internet courses provide several significant advantages over self-directed study, some of which may apply to you.

- A course structures and paces your review. It ensures that you keep going forward without getting bogged down in one subject.
- A course focuses you on a limited amount of material. Without a course, you might not know which subjects to study.
- A course provides you with the questions you need to solve. You won’t have to spend time looking for them.
- A course spoon-feeds you the material. You may not need to read the book!
- The course instructor can answer your questions when you are stuck.

You probably already know if any of these advantages apply to you. A review course will be less valuable if you are thorough, self-motivated, and highly disciplined.

**HOW LONG SHOULD YOU STUDY?**

We’ve all heard stories of the person who didn’t crack a book until the week before the exam and still passed it with flying colors. Yes, these people really exist. However, I’m not one of them, and you probably aren’t either. In fact, after having taught thousands of engineers in my own classes, I’m convinced that these people are as rare as the ones who have taken the exam five times and still can’t pass it.

A thorough review takes approximately 300 hours. Most of this time is spent solving problems. Some of it may be spent in class; some is spent at home. Some examinees spread this time over a year. Others try to cram it all into two months. Most classroom review courses last for three or four months. The best time to start studying will depend on how much time you can spend per week.

**WHAT THE WELL-HEELED MECHANICAL ENGINEER SHOULD BEGIN ACCUMULATING**

There are many references and resources that you should begin to assemble for review and for use in the examination.

It is unlikely that you could pass the PE exam without accumulating other books and resources. There
Problems for the Mechanical Engineering PE Exam will satisfy several needs. For example, ASHRAE's Handbook of Fundamentals is cited by examinees as being particularly useful to them. This listing only includes the major “named” books that have become standard references in the industry. These books are in addition to any textbooks or resources that you might choose to bring. Some of the items (particularly anything in loose-sheet form) may not be permitted in the examination room but will still be valuable during your studies. In some cases, one book will satisfy several needs. For example, ASHRAE’s Handbook of Fundamentals contains a lot of useful data for fluids, thermodynamics, HVAC, and heat transfer problems.

**ADDITIONAL REVIEW MATERIAL**

In addition to this book and its accompanying Practice Problems for the Mechanical Engineering PE Exam, PPI can provide you with many targeted references and study aids, some of which are listed here. All of these books have stood the test of time, which means that examinees continually report their usefulness and that PPI keeps them up-to-date.

- Mechanical Engineering Practice Examination
- Quick Reference for the Mechanical Engineering PE Exam
- Engineering Unit Conversions
- Mechanical Engineering Solved Problems
- PPI books in the Six-Minute series

**DON’T FORGET THE DOWNLOADS**

Many of the tables and appendices in this book are representative abridgments with just enough data to (a) do the practice problems in the companion book and (b) give you a false sense of security. You can download or link to additional data, explanations, and references by visiting PPI’s website, www.ppi2pass.com/MEwebrefs, where links to additional “Engineering Exam Support” sources are provided.

**WHAT YOU WON’T NEED**

Generally, people bring too many things to the examination. One general rule is that you shouldn’t bring books that you have not looked at during your review. If you didn’t need a book while doing the practice problems in this book, you won’t need it during the exam.

There are some other things that you won’t need.

- Books on basic and introductory subjects: You won’t need books that cover trigonometry, geometry, or calculus.
- Books that cover background engineering subjects that appear on the exam, such as fluids, thermodynamics, and chemistry: The exam is more concerned with the applications of these bodies of knowledge than with the bodies of knowledge themselves.
- Books on non-exam subjects: Such subjects as drafting, operations research, materials science, structural analysis, seismic design, history, the English language, geography, and philosophy are not part of the exam.
- Books on mathematical analysis, numerical analysis, or extensive mathematics tabulations
- Extensive collections of properties: You will not be expected to know the properties and characteristics of chemical compounds, obscure or exotic alloys, uncommon liquids and gases, or biological organisms. Most characteristics affecting performance are provided as part of the question statement.
- Building, plumbing, electrical, or fire codes
- Obscure books and materials: Books that are in foreign languages, doctoral theses, and papers presented at technical societies won’t be needed during the exam.
- Old textbooks or obsolete, rare, and ancient books: NCEES exam committees are aware of which textbooks are in use. Material that is available only in out-of-print publications and old editions won’t be used.
- Handbooks in other disciplines: You probably won’t need a civil, electrical, or industrial engineering handbook.
- The Handbook of Chemistry and Physics
Table 3  What the Well-Heeled Mechanical Engineer Would Take to the Exam

<table>
<thead>
<tr>
<th>Table 3</th>
<th>P.M. session</th>
<th>A.M. session</th>
<th>HVAC and refrigeration</th>
<th>mechanical systems and materials</th>
<th>thermal and fluids systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>psychrometric charts(^a)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ruler(^b)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>steam tables(^c)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mollier diagrams(^d)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>air tables(^e)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>compressible flow tables(^f)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marks’ Handbook(^g)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Machinery’s Handbook(^h)</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>TEMA Standards(^i)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>detailed heat transfer book(^j)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>detailed HVAC book(^k)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>extensive refrigerant data(^l)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>machine design book(^m)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formulas for Stress and Strain(^n)</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>detailed fluids data book(^o)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>NFPA Standards(^p)</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>management science book(^q)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English dictionary(^r)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>book of unit conversions</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>various ASHRAE standards(^s)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*psychrometric charts: approximately 10 for normal temperature and pressure, and several each for low-pressure, low-temperature, and high-temperature problems. (Available directly from ASHRAE.)

\(^b\)ruler: long, flexible, clear plastic ruler marked in tenths of an inch or in centimeters and millimeters.

\(^c\)steam tables: detailed tables in both English and SI units (e.g., the old *Steam Tables* by Keenan and Keyes or *ASME Steam Tables*).

\(^d\)Mollier diagrams: large diagrams in both English and SI units (as contained in the old *Steam Tables* by Keenan and Keyes or in the *ASME Steam Tables*; alternatively, the stand-alone *ASME Mollier Diagram*).

\(^e\)air tables: detailed tables in both English and SI units (e.g., the old *Gas Tables* by Keenan and Kaye).

\(^f\)compressible flow tables: isentropic flow and normal shock factors for various ratios of specific heats (as contained in *Gas Tables* by Keenan and Kaye)

\(^g\)Marks’ Handbook for Mechanical Engineers: any reasonably current edition.

\(^h\)Machinery’s Handbook: any reasonably current edition with AGMA gear data.

\(^i\)Standards of the Tubular Exchanger Manufacturers Association (“TEMA Standards”): specifically for the heat exchanger correction factors.

\(^j\)heat transfer book: with the following charts, figures, or tables: charts for solving transient heat flow problems (simple solids other than spheres); radiation arrangement factors, $F_r$; and correction factors, $F_c$, for multiple-pass heat exchangers (counterflow, crossflow, etc.), same as contained in TEMA Standards.

\(^k\)HVAC book: the gold standard is the three-volume set of ASHRAE Handbooks. There are two fallback positions: (1) One of the three handbooks, ASHRAE’s *Handbook of Fundamentals*, with the following charts, figures, or tables of data: outside design conditions versus geographic location (including winter design temperature; winter degree days; summer design temperature; summer degree days; average temperature swing; wind velocity; $k$- or $U$-values for various wall constructions; infiltration coefficients; heat loss coefficient for the slab-edge method; equivalent temperature differences and related CLTD support tables; cooling load factors (various)); (2) ASHRAE’s *ASHRAE Pocket Guide for Air Conditioning, Heating, Ventilation, Refrigeration, Inch-Pound edition* (provides abbreviated construction and weather data).

\(^l\)refrigerant data: A collection of thermodynamic property data for common refrigerants, notably R-134a, R-11, R-12, R-22, and ammonia. Data should be available in customary U.S. units in the form of saturation tables (by temperature and pressure both), $T-s$ charts, and $p-h$ charts.

\(^m\)machine design book: such as *Shigley’s Mechanical Engineering Design*. Since basic machine design changes slowly, it is not necessary to have the latest edition. Machine design books will cover the topic that NCEES has renamed “mechanical systems and materials.”

\(^n\)Roark’s *Formulas for Stress and Strain* by Young, Budynas, and Sadegh. This is good for obscure configurations requiring stress or vibration analysis. Any reasonably current edition.

\(^o\)fluids data book: such as *Crane’s Flow of Fluids Through Valves, Fittings, and Pipe (Technical Paper 410)*, *Flowserve’s Cameron Hydraulic Data*, or Colt Industries’ *Hydraulic Handbook*.

(continued)
The text of federal acts, policies, and treaties such as the Clean Air Act, Clean Water Act, Resource Recovery and Conservation Act, Oil Pollution Act, Atomic Energy Act, and Nuclear Waste Policy Act.

- Manufacturer’s literature and catalogs: No part of the exam requires you to be familiar with products that are proprietary to any manufacturer.

- U.S. government publications: With the exceptions of the publications mentioned and referenced in this book, no government publications are required in the PE exam.

- The text of federal acts, policies, and treaties such as the Clean Air Act, Clean Water Act, Resource Recovery and Conservation Act, Oil Pollution Act, Atomic Energy Act, and Nuclear Waste Policy Act.

- Your state’s laws: The PE exam is a national exam. Nothing unique to your state will appear on it. (However, federal legislation affecting engineers, particularly in environmental areas, is fair game.)

- Local, state, or national building codes

**SHOULD YOU LOOK FOR OLD EXAMS?**

The traditional approach to preparing for standardized tests includes working sample tests. However, NCEES does not release old tests or questions after they are used. Therefore, there are no official questions or tests available from legitimate sources. NCEES publishes booklets of sample questions and solutions to illustrate the format of the exam. However, these questions have been compiled from various previous exams, and the resulting publication is not a true “old exam.” Furthermore, NCEES sometimes constructs its sample questions books from questions that have been pulled from active use for various reasons, including poor performance. Such marginal questions, while accurately reflecting the format of the examination, are not always representative of actual exam subjects.

**WHAT SHOULD YOU MEMORIZE?**

You get lucky here, because it isn’t necessary to actually memorize anything. The exam is open-book, so you can look up any procedure, formula, or piece of information that you need. You can speed up your problem-solving response time significantly if you don’t have to look up the conversion from ft-lbf/sec to horsepower, the definition of the sine of an angle, and the chemical formula for carbon dioxide, but you don’t even have to memorize these simple things. As you work practice problems in the companion book, you will automatically memorize the things that you come across more than a few times.

**DO YOU NEED A REVIEW SCHEDULE?**

It is important that you develop and adhere to a review outline and schedule. Once you have decided which subjects you are going to study, you can allocate the available time to those subjects in a manner that makes sense to you. If you are not taking a classroom review course (where the order of preparation is determined by the lectures), you should make an outline of subjects for self-study to use for scheduling your preparation. A fill-in-the-dates schedule is provided in Table 4 at the end of this Introduction. If you purchased this book directly from PPI, you’ll also have access to an interactive, adjustable, and personalized study schedule. Log on to your PPI account to access your custom study schedule.

**A SIMPLE PLANNING SUGGESTION**

Designate some location (a drawer, a corner, a cardboard box, or even a paper shopping bag left on the floor) as your “exam catch-all.” Use your catch-all during the months before the exam when you have revelations about things you should bring with you. For example, you might realize that the plastic ruler marked off in tenths of an inch that is normally kept in the kitchen junk drawer can help you with some psychrometric chart questions. Or, you might decide that a certain book is particularly valuable. Or, that it would be nice to have dental floss after lunch. Or, that large rubber bands and clips are useful for holding books open.
It isn’t actually necessary to put these treasured items in the catch-all during your preparation. You can, of course, if it’s convenient. But if these items will have other functions during the time before the exam, at least write yourself a note and put the note into the catch-all. When you go to pack your exam kit a few days before the exam, you can transfer some items immediately, and the notes will be your reminders for the other items that are back in the kitchen drawer.

**HOW YOU CAN MAKE YOUR REVIEW REALISTIC**

In the exam, you must be able to quickly recall solution procedures, formulas, and important data. You must remain sharp for eight hours or more. When you played a sport back in school, your coach tried to put you in game-related situations. Preparing for the PE exam isn’t much different from preparing for a big game. Some part of your preparation should be realistic and representative of the examination environment.

There are several things you can do to make your review more representative. For example, if you gather most of your review resources (i.e., books) in advance and try to use them exclusively during your review, you will become more familiar with them. (Of course, you can also add to or change your references if you find inadequacies.)

Learning to use your time wisely is one of the most important lessons you can learn during your review. You will undoubtedly encounter questions that end up taking much longer than you expected. In some instances, you will cause your own delays by spending too much time looking through books for things you need (or just by looking at the books themselves!). Other times, the questions will entail too much work. Learn to recognize these situations so that you can make an intelligent decision about skipping such questions in the exam.

**WHAT TO DO A FEW DAYS BEFORE THE EXAM**

There are a few things you should do a week or so before the examination. You should arrange for childcare and transportation. Since the examination does not always start or end at the designated time, make sure that your childcare and transportation arrangements are flexible.

Check PPI’s website for last-minute updates and errata to any PPI books you might have and are bringing to the exam.

Prepare a separate copy of this book’s index. You may be able to photocopy the actual index; alternatively, you may find the index to the current edition of this book as a download at [www.ppi2pass.com/mermindex](http://www.ppi2pass.com/mermindex).

If you haven’t already done so, read the “Advice from Examinees” section of PPI’s website.

If you haven’t been following along on the Engineering Exam Forum on PPI’s website, use the search function to locate relevant discussions.

If it’s convenient, visit the exam location in order to find the building, parking areas, examination room, and restrooms. If it’s not convenient, you may find driving directions and/or site maps on the web.

Take the battery cover off your calculator and check to make sure you are bringing the correct size replacement batteries. Some calculators require a different kind of battery for their “permanent” memories. Put the cover back on and secure it with a piece of masking tape. Write your name on the tape to identify your calculator.

If your spare calculator is not the same as your primary calculator, spend a few minutes familiarizing yourself with how it works. In particular, you should verify that your spare calculator is functional.

**PREPARE YOUR CAR**

- Gather snow chains, shovel, and tarp to lie on while installing chains.
- Check tire pressures.
- Check your spare tire.
- Check for tire installation tools.
- Verify that you have the vehicle manual.
- Check fluid levels (oil, gas, water, brake fluid, transmission fluid, window-washing solution).
- Fill up with gas.
- Check battery and charge if necessary.
- Know something about your fuse system (where they are, how to replace them, etc.).
- Assemble all required maps.
- Fix anything that might slow you down (missing wiper blades, etc.).
- Check your taillights.
- Affix the recently arrived DMV license sticker.
- Fix anything that might get you pulled over on the way to the exam (burned-out taillight or headlight, broken lenses, bald tires, missing license plate, noisy muffler).
- Treat the inside windows with anti-fog solution.
- Put a roll of paper towels in the back seat.
- Gather exact change for any bridge tolls or toll roads.
- Find your electronic toll tag (FasTrak®/E-Z Pass®, etc.).
- Put $20 in your glove box.
- Check for current registration and proof of insurance.
- Locate a spare door and ignition key.
- Find your AAA or other roadside-assistance cards and phone numbers.
- Plan out alternate routes.
PREPARE YOUR EXAM KITS

Second in importance to your scholastic preparation is the preparation of your two examination kits. The first kit consists of a bag, box (plastic milk crates hold up better than cardboard in the rain), or wheeled travel suitcase containing items to be brought with you into the examination room.

- letter admitting you to the examination
- photographic identification (e.g., driver’s license)
- this book
- a separate, bound copy of this book’s index
  (a printable copy can be downloaded at www.ppi2pass.com/mermindex)
- other textbooks and reference books
- regular dictionary
- review course notes in a three-ring binder
- cardboard boxes or plastic milk crates to use as bookcases
- primary calculator
- spare calculator
- instruction booklets for your calculators
- extra calculator batteries
- straightedge and rulers
- compass
- protractor
- scissors
- stapler
- transparent tape
- psychrometric charts (punched in a three-ring binder)
- magnifying glass
- small (jeweler’s) screwdriver for fixing your glasses or for removing batteries from your calculator
- unobtrusive (quiet) snacks or candies, already unwrapped
- two small plastic bottles of water
- travel pack of tissue (keep in your pocket)
- handkerchief
- headache remedy
- personal medication
- $5.00 in assorted coinage
- spare contact lenses and wetting solution
- backup reading glasses
- eye drops
- light, comfortable sweater
- loose shoes or slippers
- cushion for your chair
- earplugs
- wristwatch with alarm
- several large trash bags (“raincoats” for your boxes of books)
- roll of paper towels
- wire coat hanger (to hang up your jacket or to get back into your car in an emergency)
- extra set of car keys on a string around your neck

The second kit consists of the following items and should be left in a separate bag or box in your car in case they are needed.

- copy of your application
- proof of delivery
- light lunch
- beverage in thermos or cans
- sunglasses
- extra pair of prescription glasses
- raincoat, boots, gloves, hat, and umbrella
- street map of the examination area
- parking permit
- battery-powered desk lamp
- your cell phone
- length of rope

The following items cannot be used during the examination and should be left at home.

- personal pencils and erasers (NCEES distributes mechanical pencils at the exam.)
- fountain pens
- radio, CD player, or iPod™
- battery charger
- extension cords
- scratch paper
- note pads

PREPARE FOR THE WORST

All of the occurrences listed in this section have happened to examinees. Granted, you cannot prepare for every eventuality. But, even though each of these occurrences taken individually is a low-probability event, taken together, they are worth considering in advance.

- Imagine getting a flat tire, getting stuck in traffic, or running out of gas on the way to the exam.
- Imagine rain and snow as you are carrying your cardboard boxes of books into the exam room. Would plastic trash bags be helpful?
- Imagine arriving late. Can you get into the exam without having to make two trips from your car?
- Imagine having to park two blocks from the exam site. How are you going to get everything to the exam room? Can you actually carry everything that far? Could you use a furniture dolly, a supermarket basket, or perhaps a helpmate?
- Imagine a Star Trek convention, square-dancing contest, construction, or auction in the next room.
- Imagine a site without any heat, with poor lighting, or with sunlight streaming directly into your eyes.
- Imagine a hard folding chair and a table with one short leg.
• Imagine a site next to an airport with frequent take-offs, or next to a construction site with a pile driver, or next to the NHRA’s Drag Racing Championship.

• Imagine a seat where someone nearby chews gum with an open mouth; taps his pencil or drums her fingers; or wheezes, coughs, and sneezes for eight hours.

• Imagine the distraction of someone crying or of proctors evicting yelling and screaming examinees who have been found cheating.

• Imagine the tragedy of another examinee’s serious medical emergency.

• Imagine a delay of an hour while they find someone to unlock the building, turn on the heat, or wait for the head proctor to bring instructions.

• Imagine a power outage occurring sometime during the exam.

• Imagine a proctor who (a) tells you that one of your favorite books can’t be used in the exam, (b) accuses you of cheating, or (c) calls “time up” without giving you any warning.

• Imagine not being able to get your lunch out of your car or find a restaurant

• Imagine getting sick or nervous in the exam.

• Imagine someone stealing your calculator during lunch.

WHAT TO DO THE DAY BEFORE THE EXAM

Take the day before the examination off from work to relax. Do not cram the last night. A good night’s sleep is the best way to start the examination. If you live a considerable distance from the examination site, consider getting a hotel room in which to spend the night.

Practice setting up your examination work environment. Carry your boxes to the kitchen table. Arrange your “bookcases” and supplies. Decide what stays on the floor in boxes and what gets an “honored position” on the tabletop.

Use your checklist to make sure you have everything. Make sure your exam kits are packed and ready to go. Wrap your boxes in plastic bags in case it’s raining when you carry them from the car to the exam room.

Calculate your wake-up time and set the alarms on two bedroom clocks. Select and lay out your clothing items. (Dress in layers.) Select and lay out your breakfast items.

If it’s going to be hot on exam day, put your (plastic) bottles of water in the freezer.

Make sure you have gas in your car and money in your wallet.

WHAT TO DO THE DAY OF THE EXAM

Turn off the quarterly and hourly alerts on your wrist-watch. Leave your pager or cell phone at home. If you must bring them, change them to silent mode. Bring or buy a morning newspaper.

You should arrive at least 30 minutes before the examination starts. This will allow time for finding a convenient parking place, bringing your materials to the examination room, making room and seating changes, and calming down. Be prepared, though, to find that the examination room is not open or ready at the designated time.

Once you have arranged the materials around you on your table, take out your morning newspaper and look cool. (Only nervous people work crossword puzzles.)

WHAT TO DO DURING THE EXAM

All of the procedures typically associated with timed, proctored, computer-graded assessment tests will be in effect when you take the PE examination.

The proctors will distribute the examination booklets and answer sheets if they are not already on your tables. However, you should not open the booklets until instructed to do so. You may read the information on the front and back covers, and you should write your name in any appropriate blank spaces.

Listen carefully to everything the proctors say. Do not ask your proctors any engineering questions. Even if they are knowledgeable in engineering, they will not be permitted to answer your questions.

Answers to questions are recorded on an answer sheet contained in the test booklet. The proctors will guide you through the process of putting your name and other biographical information on this sheet when the time comes, which will take approximately 15 minutes. You will be given the full four hours to answer questions. Time to initialize the answer sheet is not part of your four hours.

The common suggestions to “completely fill the bubbles and erase completely” apply here. NCEES provides each examinee with a mechanical pencil with HB lead. Use of ballpoint pens and felt-tip markers is prohibited for several reasons.

If you finish the exam early and there are still more than 30 minutes remaining, you will be permitted to leave the room. If you finish less than 30 minutes before the end of the exam, you may be required to remain until the end. This is done to be considerate of the people who are still working.

Be prepared to stop working immediately when the proctors call “pencils down” or “time is up.” Continuing to work for even a few seconds will completely invalidate your examination.
When you leave, you must return your exam booklet. You may not keep the exam booklet for later review.

If there are any questions that you think were flawed, in error, or unsolvable, ask a proctor for a “reporting form” on which you can submit your comments. Follow your proctor’s advice in preparing this document.

WHAT ABOUT EATING AND DRINKING IN THE EXAM ROOM?

The official rule is probably the same in every state: no eating or drinking in the exam. That makes sense, for a number of reasons. Some exam sites don’t want (or don’t permit) stains and messes. Others don’t want crumbs to attract ants and rodents. Your table partners don’t want spills or smells. Nobody wants the distractions. Your proctors can’t give you a new exam booklet when the first one is ruined with coffee.

How this rule is administered varies from site to site and from proctor to proctor. Some proctors enforce the letter of law, threatening to evict you from the exam room when they see you chewing gum. Others may permit you to have bottled water, as long as you store the bottles on the floor where any spills will not harm what’s on the table. No one is going to let you crack peanuts while you work on the exam, but I can’t see anyone complaining about a hard candy melting away in your mouth. You’ll just have to find out when you get there.

HOW TO SOLVE MULTIPLE-CHOICE QUESTIONS

When you begin each session of the exam, observe the following suggestions:

• Use only the pencil provided.
• Do not spend an inordinate amount of time on any single question. If you have not answered a question in a reasonable amount of time, make a note of it and move on.
• Set your vibrating wristwatch alarm for five minutes before the end of each four-hour session, and use that remaining time to guess at all of the remaining questions. Odds are that you will be successful with about 25% of your guesses, and these points will more than make up for the few points that you might earn by working during the last five minutes.
• Make mental notes about any questions for which you cannot find a correct response, that appears to have two correct responses, or that you believe have some technical flaw. Errors in the exam are rare, but they do occur. Such errors are usually discovered during the scoring process and discounted from the examination, so it is not necessary to tell your proctor, but be sure to mark the one best answer before moving on.
• Make sure all of your responses on the answer sheet are dark and completely fill the bubbles.

SOLVE QUESTIONS CAREFULLY

Many points are lost to carelessness. Keep the following items in mind when you are solving the end-of-chapter questions. Hopefully, these suggestions will be automatic in the exam.

[ ] Did you recheck your mathematical equations?
[ ] Did you cancel out in your calculations?
[ ] Did you convert between radius and diameter?
[ ] Did you convert between feet and inches?
[ ] Did you convert from gage to absolute pressures?
[ ] Did you convert between pounds and kips, or kPa and Pa?
[ ] Did you use the universal gas constant that corresponds to the set of units used in the calculation?
[ ] Did you recheck all data obtained from other sources, tables, and figures? (In finding the friction factor, did you enter the Moody diagram at the correct Reynolds number?)

SHOULD YOU TALK TO OTHER EXAMINEES AFTER THE EXAM?

The jury is out on this question. People react quite differently to the examination experience. Some people are energized. Most are exhausted. Some people need to unwind by talking with other examinees, describing every detail of their experience, and dissecting every examination question. Other people need lots of quiet space, and prefer to just get into a hot tub to soak and sulk. Most engineers, apparently, are in this latter category.

Since everyone who took the exam has seen it, you will not be violating your “oath of silence” if you talk about the details with other examinees immediately after the exam. It’s difficult not to ask how someone else approached a question that had you completely stumped. However, keep in mind that it is very disquieting to think you answered a question correctly, only to have someone tell you where you went wrong.

To ensure you do not violate the nondisclosure agreement you signed before taking the exam, make sure you do not discuss any exam particulars with people who have not also taken the exam.

AFTER THE EXAM

Yes, there is something to do after the exam. Most people return home, throw their exam “kits” into the corner, and collapse. A week later, when they can bear to think about the experience again, they start integrating their exam kits back into their normal lives. The calculators go back into the desk, the books go back on the shelves, the $5.00 in change goes back into the piggy bank, and all of the miscellaneous stuff you brought with you to the exam is put back wherever it came from.
Here’s what I suggest you do as soon as you get home, before you collapse.

[ ] Thank your spouse and children for helping you during your preparation.
[ ] Take any paperwork you received on exam day out of your pocket, purse, or wallet. Put this inside your *Mechanical Engineering Reference Manual*.
[ ] Reflect on any statements regarding exam secrecy to which you signed your agreement in the exam.
[ ] If you participated in a PPI Passing Zone, log on one last time to thank the instructors. (Passing Zones remain open for a week after the exam.)
[ ] Call your employer and tell him/her that you need to take a mental health day off on Monday.

A few days later, when you can face the world again, do the following.

[ ] Make notes about anything you would do differently if you had to take the exam over again.
[ ] Consolidate all of your application paperwork, correspondence to/from your state, and any paperwork that you received on exam day.
[ ] If you took a live review course, call or email the instructor (or write a note) to say “Thanks.”
[ ] Visit the Engineering Exam Forum part of PPI’s website and see what other people are saying about the exam you took.
[ ] Return any books you borrowed.
[ ] Write thank-you notes to all of the people who wrote letters of recommendation or reference for you.
[ ] Find and read the chapter in this book that covers ethics. There were no ethics questions on your PE exam, but it doesn’t make any difference. Ethical behavior is expected of a PE in any case. Spend a few minutes reflecting on how your performance (obligations, attitude, presentation, behavior, appearance, etc.) might be about to change once you are licensed. Consider how you are going to be a role model for others around you.
[ ] Put all of your review books, binders, and notes someplace where they will be out of sight.

**FINALLY**

By the time you’ve “undone” all of your preparations, you might have thought of a few things that could help future examinees. If you have any sage comments about how to prepare, any suggestions about what to do in or bring to the exam, any comments on how to improve this book, or any funny anecdotes about your experience, I hope you will share these with me. By this time, you’ll be the “expert,” and I’ll be your biggest fan.

**AND THEN, THERE’S THE WAIT...**

Waiting for the exam results is its own form of mental torture.

Yes, I know the exam is 100% multiple-choice, and grading should be almost instantaneous. But, you are going to wait, nevertheless. There are many reasons for the delay.

Although the actual machine grading “only takes seconds,” consider the following facts: (a) NCEES prepares multiple exams for each administration, in case one becomes unusable (i.e., is inappropriately released) before the exam date. (b) Since the actual version of the exam used is not known until after it is finally given, the cut-score determination occurs after the exam date.

I wouldn’t be surprised to hear that NCEES receives dozens, if not hundreds, of claims from well-meaning examinees who were 100% certain that the exams they took were seriously flawed to some degree—that there wasn’t a correct answer for such-and-such question—that there were two answers for such-and-such question—or even, perhaps, that such-and-such question was missing from their exam booklet altogether. Each of these claims must be considered as a potential adjustment to the cut score.

Then, the exams must actually be graded. Since grading nearly 50,000 exams (counting all the FE and PE exams) requires specialized equipment, software, and training not normally possessed by the average employee, as well as time to do the work (also not normally possessed by the average employee), grading is invariably outsourced.

Outsourced grading cannot begin until all of the states have returned their score sheets to NCEES and NCEES has sorted, separated, organized, and consolidated the score sheets into whatever “secret sauce sequence” is best. During grading, some of the score sheets “pop out” with any number of abnormalities that demand manual scoring.

After the individual exams are scored, the results are analyzed in a variety of ways. Some of the analysis looks at passing rates by such delineators as degree, major, university, site, and state. Part of the analysis looks for similarities between physically adjacent examinees (to look for cheating). Part of the analysis looks for exam sites that have statistically abnormal group performance. And, some of the analysis looks for exam questions that have a disproportionate fraction of successful or unsuccessful examinees. Anyway, you get the idea: It’s not merely putting your exam sheet in an electronic reader. All of these steps have to be completed for 100% of the examinees before any results can go out.

Once NCEES has graded your test and notified your state, when you hear about it depends on when the work is done by your state. Some states have to approve the results at a board meeting; others prepare the certificates before sending out notifications. Some states are
more computerized than others. Some states have 50 examinees, while others have 10,000. Some states are shut down by blizzards and hurricanes; others are administratively challenged—understaffed, inadequately trained, or over budget.

There is no pattern to the public release of results. None. The exam results are not released to all states simultaneously. (The states with the fewest examinees often receive their results soonest.) They are not released by discipline. They are not released alphabetically by state or examinee name. The people who failed are not notified first (or last). Your coworker might receive his or her notification today, and you might be waiting another three weeks for yours.

Some states post the names of the successful examinees, or unsuccessful examinees, or both on their official state websites before the results go out. Others update their websites after the results go out. Some states don’t list much of anything on their websites.

Remember, too, that the size or thickness of the envelope you receive from your state does not mean anything. Some states send a big congratulations package and certificate. Others send a big package with a new application to repeat the exam. Some states send a postcard. Some send a one-page letter. Some states send you an invoice for your license fees. (Ahh, what a welcome bill!) You just have to open it to find out.

Check the Engineering Exam Forum on the PPI website regularly to find out which states have released their results. You will find many other anxious examinees there. And any number of humorous conspiracy theories and rumors.

While you are waiting, I hope you will become a “Forum” regular. Log on often and help other examinees by sharing your knowledge, experiences, and wisdom.

AND WHEN YOU PASS...

[ ] Celebrate.
[ ] Notify the people who wrote letters of recommendation or reference for you.
[ ] Read “FAQs about What Happens After You Pass the Exam” on PPI’s website.
[ ] Ask your employer for a raise.
[ ] Tell the folks at PPI (who have been rootin’ for you all along) the good news.
### Table 4 Schedule for Self-Study

<table>
<thead>
<tr>
<th>chapter number</th>
<th>subject</th>
<th>date to start</th>
<th>date to finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Systems of Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Engineering Drawing Practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Algebra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Linear Algebra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Vectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Trigonometry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Analytic Geometry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Differential Calculus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Integral Calculus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Differential Equations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Probability and Statistical Analysis of Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Numbering Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Numerical Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Fluid Properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Fluid Statics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Fluid Flow Parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Fluid Dynamics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Hydraulic Machines and Fluid Distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Hydraulic and Pneumatic Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Inorganic Chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Fuels and Combustion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Energy, Work, and Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Thermodynamic Properties of Substances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Changes in Thermodynamic Properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Compressible Fluid Dynamics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Vapor Power Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Vapor Power Cycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Reciprocating Combustion Engine Cycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Combustion Turbine Cycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Nuclear Power Cycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Advanced and Alternative Power-Generating Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Gas Compression Cycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Refrigeration Cycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Fundamental Heat Transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Natural Convection, Evaporation, and Condensation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Forced Convection and Heat Exchangers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Radiation and Combined Heat Transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Psychrometrics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Cooling Towers and Fluid Coolers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chapter number</td>
<td>subject</td>
<td>date to start</td>
<td>date to finish</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------------------------</td>
<td>---------------</td>
<td>----------------</td>
</tr>
<tr>
<td>40</td>
<td>Ventilation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Fans, Ductwork, and Terminal Devices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Heating Load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Cooling Load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Air Conditioning Systems and Controls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Determinate Statics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Indeterminate Statics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Engineering Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Material Properties and Testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Thermal Treatment of Metals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Properties of Areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Strength of Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Failure Theories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Basic Machine Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Advanced Machine Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Pressure Vessels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>Properties of Solid Bodies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Kinematics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>Kinetics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>Mechanisms and Power Transmission Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Vibrating Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>Modeling of Engineering Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>Analysis of Engineering Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>Management Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>Instrumentation and Measurements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>Manufacturing Processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Materials Handling and Processing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>Fire Protection Sprinkler Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>Pollutants in the Environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Storage and Disposition of Hazardous Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Testing and Sampling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>Environmental Remediation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>Electricity and Electrical Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>Illumination and Sound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>Engineering Economic Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>Professional Services, Contracts, and Engineering Law</td>
<td></td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>Engineering Ethics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>