Introduction

PART 1: ABOUT THIS BOOK

This book is intended to guide you through the Other Disciplines Fundamentals of Engineering (FE) examination body of knowledge and the idiosyncrasies of the National Council of Examiners for Engineers and Surveyors (NCEES) *FE Reference Handbook* (*NCEES Handbook*). This book is not intended as a reference book, because you cannot use it while taking the FE examination. The only reference you may use is the *NCEES Handbook*. However, the *NCEES Handbook* is not intended as a teaching tool, nor is it an easy document to use. The *NCEES Handbook* was never intended to be something you study or learn from, or to have value as anything other than an exam-day compilation. Many of its features may distract you because they differ from what you were expecting, were exposed to, or what you currently use.

To effectively use the *NCEES Handbook*, you must become familiar with its features, no matter how odd they may seem. *FE Other Disciplines Review Manual* will help you become familiar with the format, layout, organization, and odd conventions of the *NCEES Handbook*. This book, which displays the *NCEES Handbook* material in blue for easy identification, satisfies two important needs: it is (1) something to learn from, and (2) something to help you become familiar with the *NCEES Handbook*.

Organization

This book is organized into topics (e.g., "Strength of Materials") that correspond to the knowledge areas listed by NCEES in its Other Disciplines FE exam specifications. However, unlike the *NCEES Handbook*, this book arranges subtopics into chapters (e.g., "Stresses and Strains") that build logically on one another. Each chapter contains sections (e.g., "Mohr's Circle") organized around *NCEES Handbook* equations, but again, the arrangement of those equations is based on logical development, not the *NCEES Handbook*. Equations that are presented together in this book may actually be many pages apart in the *NCEES Handbook*.

The presentation of each subtopic or related group of equations uses similar components and follows a specific sequence. The components of a typical subtopic are:

- general section title
- background and developmental content
- equation name (or description) and equation number
- equation with *NCEES Handbook* formatting
- any relevant variations of the equation
- any values typically associated with the equation
- additional explanation and development
- worked quantitative example using the *NCEES Handbook* equation
- footnotes

Not all sections contain all of these features. Some features may be omitted if they are not needed. For example, "$g = 9.81\ \text{m/s}^2$" would be a typical value associated with the equation $W = mg$. There would be no typical values associated with the equation $F = ma$.

Much of the information in this book and in the *NCEES Handbook* is relevant to more than one knowledge area or subtopic. For example, equations related to the Fluid Mechanics and Dynamics of Liquids knowledge area also pertain to Fluid Mechanics and Dynamics of Gases. Many Strength of Materials concepts correlate with Statics subtopics. The index will help you locate all information related to any of the topics or subtopics you wish to review.

Content

This book presents equations, figures, tables, and other data equivalent to those given in the *NCEES Handbook*. For example, the *NCEES Handbook* includes tables for conversion factors, material properties, and areas and centroids of geometric shapes, so this book provides equivalent tables. Occasionally, a redundant element of the *NCEES Handbook*, or some item having no value to examinees, has been omitted.

Some elements, primarily figures and tables, that were originally published by authoritative third parties (and for whom reproduction permission has been granted) have been reprinted exactly as they appear in the *NCEES Handbook*. Other elements have been editorially and artistically reformulated, but they remain equivalent in utility to the originals.

Colors

Due to the selective nature of topics included in the *NCEES Handbook*, coverage of some topics in the *NCEES Handbook* may be incomplete. This book aims to offer more comprehensive coverage, and so, it contains material that is not covered in the *NCEES*

Handbook. This book uses color to differentiate between what is available to you during the exam, and what is supplementary content that makes a topic more interesting or easier to understand. Anything that closely parallels or duplicates the *NCEES Handbook* is printed in blue. Headings that introduce content related to *NCEES Handbook* equations are printed in blue. Titles of figures and tables that are essentially the same as in the *NCEES Handbook* are similarly printed in blue. Headings that introduce sections, equations, figures, and tables that are NOT in the *NCEES Handbook* are printed in **black**. The **black** content is background, preliminary and supporting material, explanations, extensions to theory, and application rules that are generally missing from the *NCEES Handbook*.

Numbering

The equations, figures, and tables in the *NCEES Handbook* are unnumbered. All equations, figures, and tables in this book include unique numbers provided to help you navigate through the content.

You will find many equations in this book that have no numbers and are printed in **black**, not blue. These equations represent instructional material, often missing pieces or interim results not presented in the *NCEES Handbook*. In some cases, the material was present in the eighth edition of the *NCEES Handbook*, but is absent in the ninth edition. In some cases, I included instruction in deleted content. (This book does not contain all of the deleted *NCEES Handbook* eighth edition content, however.)

Equation and Variable Names

This book generally uses the *NCEES Handbook* terminology and naming conventions, giving standard, normal, and customary alternatives within parentheses or footnotes. For example, the *NCEES Handbook* refers to what is commonly known as Bernoulli equation as the "energy equation." This book acknowledges the *NCEES Handbook* terminology when introducing the equation, but uses the term "Bernoulli equation" thereafter.

Variables

This book makes every effort to include the *NCEES Handbook* equations exactly as they appear in the *NCEES Handbook*. While any symbol can be defined to represent any quantity, in many cases, the *NCEES Handbook*'s choice of variables will be dissimilar to what most engineers are accustomed to. For example, although there is no concept of weight in the SI system, the *NCEES Handbook* defines W as the symbol for weight with units of newtons. While engineers are comfortable with E, E_k, KE, and U representing kinetic energy, after introducing KE in its introductory pages, the *NCEES Handbook* uses T (which is used sparingly by some scientists) for kinetic energy. The *NCEES Handbook* designates power as $\dot{W}$ instead of P. The *NCEES Handbook* uses Greek omega, ω, to represent water content, rather than the industry-standard w. Because you have to be familiar with them, this book reluctantly follows all of those conventions.

This book generally follows the *NCEES Handbook* convention regarding use of italic fonts, even when doing so results in ambiguity. For example, as used by the *NCEES Handbook*, aspect ratio, AR, is indistinguishable from $A \times R$, area times radius. Occasionally, the *NCEES Handbook* is inconsistent in how it represents a particular variable, or in some sections, it drops the italic font entirely and presents all of its variables in roman font. This book maintains the publishing convention of showing all variables as italic.

There are a few important differences between the ways the *NCEES Handbook* and this book present content. These differences are intentional for the purpose of maintaining clarity and following PPI's publication policies.

- *pressure:* The *NCEES Handbook* primarily uses P for pressure, an atypical engineering convention. This book always uses p so as to differentiate it from P, which is reserved for power, momentum, and axial loading in related chapters.
- *velocity:* The *NCEES Handbook* uses v and occasionally Greek nu, ν, for velocity. This book always uses v to differentiate it from Greek upsilon, υ, which represents specific volume in some topics (e.g., thermodynamics), and Greek nu, ν, which represents absolute viscosity and Poisson's ratio.
- *specific volume:* The *NCEES Handbook* uses v for specific volume. This book always uses Greek upsilon, υ, a convention that most engineers will be familiar with.
- *units:* The *NCEES Handbook* and the FE exam generally do not emphasize the difference between pounds-mass and pounds-force. "Pounds" ("lb") can mean either force or mass. This book always distinguishes between pounds-force (lbf) and pounds-mass (lbm).

Distinction Between Mass and Weight

The *NCEES Handbook* specifies the unit weight of water, γ_w, as 9.810 N/m^3. This book follows that convention but takes every opportunity to point out that there is no concept of weight in the SI system.

Equation Formatting

The *NCEES Handbook* writes out many multilevel equations as an awkward string of characters on a single line, using a plethora of parentheses and square and curly brackets to indicate the precedence of mathematical operations. So, this book does also. However, in examples using the equations, this book reverts to normal publication style after presenting the base equation styled as it is in the *NCEES Handbook*. The change in style will show you the equations as the *NCEES*

Handbook presents them, while presenting the calculations in a normal and customary typographic manner.

Footnotes

I have tried to anticipate the kinds of questions about this book and the *NCEES Handbook* that an instructor would be asked in class. Footnotes are used in this book as the preferred method of answering those questions and of drawing your attention to features in the *NCEES Handbook* that may confuse, confound, and infuriate you. Basically, *NCEES Handbook* conventions are used within the body of this book, and any inconsistencies, oddities and unconventionalities, and occasionally, even errors, are pointed out in the footnotes.

If you know the NCEES knowledge areas backward as well as forward, many of the issues pointed out in the footnotes will seem obvious. However, if you have only a superficial knowledge of the knowledge areas, the footnotes will answer many of your questions. The footnotes are intended to be factual and helpful.

Indexed Terms

The print version of this book contains an index with thousands of terms. The index will help you quickly find just what you are looking for, as well as identify related concepts and content.

PART 2: HOW YOU CAN USE THIS BOOK

IF YOU ARE A STUDENT

In reference to Isaac Asimov's *Foundation and Empire* trilogy, you'll soon experience a Seldon crisis. Given all the factors (the exam you're taking, what you learned as a student, how much time you have before the exam, and your own personality), the behaviors (strategies made evident through action) required of you will be self-evident.

Here are some of those strategies.

Get the NCEES *FE Reference Handbook*

Get a copy of the *NCEES Handbook*. Use it as you read through this book. You will want to know the sequence of the sections, what data is included, and the approximate locations of important figures and tables in the *NCEES Handbook*. You should also know the terminology (words and phrases) used in the *NCEES Handbook* to describe equations or subjects, because those are the terms you will have to look up during the exam.

The *NCEES Handbook* is available both in printed and PDF format. The index of the print version may help you locate an equation or other information you are looking for, but few terms are indexed thoroughly. The PDF version includes search functionality that is similar to what you'll have available when taking the computer-based exam. In order to find something using the PDF search function, your search term will have to match the content exactly (including punctuation).

Diagnose Yourself

Use the diagnostic exams in this book to determine how much you should study in the various knowledge areas. You can use diagnostic exams (and, other assessments) in two ways: take them before you begin studying to determine which subjects you should emphasize, or take them after you finish studying to determine if you are ready to move on.

Make a Schedule

In order to complete your review of all examination subjects, you must develop and adhere to a review schedule. If you are not taking a live review course (where the order of your preparation is determined by the lectures), you'll want to prepare your own schedule. If you want to pencil out a schedule on paper, a blank study schedule template is provided at the end of this Introduction.

The amount of material in each chapter of this book, and the number of questions in the corresponding chapter of *FE Other Disciplines Practice Problems*, were designed to fit into a practical schedule. You should be able to review one chapter in each book each day. There are 48 chapters and 14 diagnostic exams in this book, as well as corresponding chapters of practice problems in the companion book *FE Other Disciplines Practice Problems*. So, you need at least 62 study days. This requires you to treat every day the same and work through weekends.

If you'd rather take all the weekends off and otherwise stick with the one-chapter-per-study-day concept, you will have to begin approximately 93 days before the exam. Use the off days to rest, review, and study questions from other books. If you are pressed for time or get behind schedule, you don't have to take the days off. That will be your choice.

Near the exam date, give yourself a week to take a realistic practice exam, to remedy any weaknesses it exposes, and to recover from the whole ordeal.

Work Through Everything

NCEES has greatly reduced the number of subjects about which you are expected to be knowledgeable and has made nothing optional. Skipping your weakest subjects is no longer a viable preparation strategy. You should study all examination knowledge areas, not just your specialty areas. That means you study every chapter in this book and skip nothing. Do not limit the number of chapters you study in hopes of finding enough questions in your areas of expertise to pass the exam.

Be Thorough

Being thorough means really doing the work. Read the material, don't skim it. Solve each numerical example using your calculator. Read through the solution, and refer back to the equations, figures, and tables it references.

Don't jump into answering questions without first reviewing the instructional text in this book. Unlike reference books that you skim or merely refer to when needed, this book requires you to read everything. That reading is going to be your only review. Reading the instructional text is a "high value" activity. There isn't much text to read in the first place, so the value per word is high. There aren't any derivations or proofs, so the text is useful. Everything in blue titled sections is in the *NCEES Handbook*, so it has a high probability of showing up on the exam.

Work Problems

You have less than an average of three minutes to answer each question on the exam. You must be able to quickly recall solution procedures, formulas, and important data. You will not have time to derive solution methods—you must know them instinctively. The best way to develop fast recall is to work as many practice problems as you can find, including those in the companion book *FE Other Disciplines Practice Problems*.

Solve every example in this book and every problem in *FE Other Disciplines Practice Problems*. Don't skip any of them. All of the problems were written to illustrate key points.

Finish Strong

There will be physical demands on your body during the examination. It is very difficult to remain alert, focused, and attentive for six hours or more. Unfortunately, the more time you study, the less time you have to maintain your physical condition. Thus, most examinees arrive at the examination site in high mental condition but in deteriorated physical condition. While preparing for the FE exam is not the only good reason for embarking on a physical conditioning program, it can serve as a good incentive to get in shape.

Claim Your Reward

As Hari Seldon often said in Isaac Asimov's *Foundation and Empire* trilogy, the outcome of your actions will be inevitable.

IF YOU ARE AN INSTRUCTOR

CBT Challenges

The computer-based testing (CBT) FE exam format, content, and frequent administration present several challenges to teaching a live review course. Some of the challenges are insurmountable to almost all review courses. Live review courses cannot be offered year round, a different curriculum is required for each engineering discipline, and a hard-copy, in-class mock exam taken at the end of the course no longer prepares examinees for the CBT experience. The best that instructors can do is to be honest about the limitations of their courses, and to refer examinees to any other compatible resources.

Many of the standard, tried-and-true features of live FE review courses are functionally obsolete. These obsolete features include general lectures that cover "everything," complex numerical examples with more than two or three simple steps, instructor-prepared handouts containing notes and lists of reference materials, and a hard-copy mock exam. As beneficial as those features were in the past, they are no longer best commercial practice for the CBT FE exam. However, they may still be used and provide value to examinees.

This book parallels the content of the *NCEES Handbook* and, with the exceptions listed in this Introduction, uses the same terminology and nomenclature. The figures and tables are equivalent to those in the *NCEES Handbook*. You can feel confident that I had your students and the success of your course in mind when I designed this book.

Instruction for Multiple Exams

Historically, most commercial review courses (taken primarily by engineers who already have their degrees) prepared examinees for the Other Disciplines FE examination. That is probably the only logical (practical, sustainable, etc.) course of action, even now. Few commercial review course providers have the large customer base and diverse instructors needed to offer simultaneous courses for every discipline.

University review courses frequently combine students from multiple disciplines, focusing the review course content on the core overlapping concepts and the topics covered by the Other Disciplines FE exam. The change in the FE exam scope has made it more challenging than ever to adequately prepare a diverse student group.

If you are tasked with teaching a course to examinees taking more than one exam, refer to the guidelines and suggestions posted at **feprep.com/instruct**. The materials available to review course instructors (as well as for examinees) continue to evolve, and that site will reference the most current resources available.

Lectures

Your lectures should duplicate what the examinees would be doing in a self-directed review program. That means walking through each chapter in this book in its entirety. You're basically guiding a tour through the book. By covering everything in this book, you'll cover everything on the exam.

Handouts

Everything you do in a lecture should be tied back to the *NCEES Handbook*. You will be doing your students

a great disservice if you get them accustomed to using your course handouts or notes to solve problems. They can't use your notes in the exam, so train them to use the only reference they are allowed to use.

NCEES allows that the exam may require broader knowledge than the *NCEES Handbook* contains. However, there are very few areas that require formulas not present in the *NCEES Handbook*. Therefore, you shouldn't deviate too much from the subject matter of each chapter.

Homework

Students like to see and work a lot of problems. They derive great comfort from exposure to exam-like problems. They experience great reassurance in working exam-like problems and finding out how easy the problems are. However, most students are impatient. So, the repetition and reinforcement should come from working additional problems, not from more lecture.

It is unlikely that your students will be working to capacity if their work is limited to what is in this book. You will have to provide or direct your students to more problems in order to help them effectively master the concepts you will be teaching.

Schedule

I have found that a 15-week format works best for a live FE exam review course that covers everything and is intended for working engineers who already have their degrees. This schedule allows for one 2- to $2\frac{1}{2}$-hour lecture per week, with a 10-minute break each hour.

Table 1 outlines a typical format for a live commercial Other Disciplines FE review course. To some degree, the lectures build upon one another. However, a credible decision can be made to present the knowledge areas in the order they appear in the *NCEES Handbook*.

However, a 15-week course is too long for junior and senior engineering majors still working toward a degree. College students and professors don't have that much time. And, students don't need as thorough of a review as do working engineers who have forgotten more of the fundamentals. College students can get by with the most cursory of reviews in some knowledge areas, such as mathematics, fluid mechanics, and statics.

For college students, an 8-week course consisting of six weeks of lectures followed by two weeks of open questions seems appropriate. If possible, two 1-hour lectures per week are more likely to get students to attend than a single 2- or 3-hour lecture per week. The course consists of a comprehensive march through all knowledge areas except mathematics, with the major emphasis being on problem-solving rather than lecture. For current engineering majors, the main goals are to keep the students focused and to wake up their latent memories, not to teach the subjects.

Table 2 outlines a typical format for a live university review course. The sequence of the lectures is less important for a university review course than for a commercial course, because students will have recent experience in the subjects. Some may actually be enrolled in some of the related courses while you are conducting the review.

I strongly believe in the benefits of exposing all review course participants to a realistic sample examination. Unless you have made arrangements with **feprep.com** for your students to take an online exam, you probably cannot provide them with an experience equivalent to the actual exam. A written take-home exam is better than nothing, but since it will not mimic the exam experience, it must be presented as little more than additional problems to solve.

I no longer recommend an in-class group final exam. Since a review course usually ends only a few days before the real FE examination, it seems inhumane to make students sit for hours into the late evening for the final exam. So, if you are going to use a written mock exam, I recommend distributing it at the first meeting of the review course and assigning it as a take-home exercise.

PART 3: ABOUT THE EXAM

EXAM STRUCTURE

The FE exam is a computer-based test that contains 110 multiple-choice questions given over two consecutive sessions (sections, parts, etc.). Each session contains approximately 55 multiple-choice questions that are grouped together by knowledge area (subject, topic, etc.). The subjects are not explicitly labeled, and the beginning and ending of the subjects are not noted. No subject spans the two exam sessions. That is, if a subject appears in the first session of the exam, it will not appear in the second.

Each question has four possible answer choices, labeled (A), (B), (C), and (D). Only one question and its answer choices is given onscreen at a time. The exam is not adaptive (i.e., your response to one question has no bearing on the next question you are given). Even if you answer the first five mathematics questions correctly, you'll still have to answer the sixth question.

In essence, the FE exam is two separate, partial exams given in sequence. During either session, you cannot view or respond to questions in the other session.

Your exam will include a limited (unknown) number of questions (known as "pretest items") that will not be scored and will not have an impact on your results. NCEES does this to determine the viability of new questions for future exams. You won't know which questions are pretest items. They are not identifiable and are randomly distributed throughout the exam.

Table 1 *Recommended 15-Week Other Disciplines FE Exam Review Course Format for Commercial Review Courses*

week	*FE Other Disciplines Review Manual* chapter titles	*FE Other Disciplines Review Manual* chapter numbers
1	Analytic Geometry and Trigonometry; Algebra and Linear Algebra; Calculus; Differential Equations and Transforms; Numerical Methods	1–5
2	Probability and Statistics	6
3	Systems of Forces and Moments; Trusses; Pulleys, Cables, and Friction; Centroids and Moments of Inertia	7–10
4	Kinematics; Kinetics; Kinetics of Rotational Motion; Energy and Work; Vibrations	11–15
5	Stresses and Strains; Thermal, Hoop, and Torsional Stress; Beams; Columns	16–19
6	Material Properties and Testing; Engineering Materials	20–21
7	Fluid Properties; Fluid Statics; Fluid Dynamics	22–24
8	Fluid Measurement and Similitude; Compressible Fluid Dynamics; Fluid Machines	25–27
9	Properties of Substances; Laws of Thermodynamics; Power Cycles and Entropy; Mixtures of Gases, Vapors, and Liquids; Combustion; Heat Transfer	28–33
10	Inorganic Chemistry	34
11	Electrostatics; Direct-Current Circuits; Alternating-Current Circuits; Amplifiers; Three-Phase Electricity and Power	35–39
12	Computer Software; Measurement and Instrumentation; Signal Theory and Processing; Controls	40–43
13	Safety, Health, and Environment	44
14	Engineering Economics	45
15	Professional Practice; Ethics; Licensure	46–48

EXAM DURATION

The exam is six hours long and includes an 8-minute tutorial, a 25-minute break, and a brief survey at the conclusion of the exam. The total time you'll have to actually answer the exam questions is 5 hours and 20 minutes. The problem-solving pace works out to slightly less than 3 minutes per question. However, the exam does not pace you. You may spend as much time as you like on each question. Although the onscreen navigational interface is slightly awkward, you may work through the questions (in that session) in any sequence. If you want to go back and check your answers before you submit a session for grading, you may. However, once you submit a section you are not able to go back and review it.

You can divide your time between the two sessions any way you'd like. That is, if you want to spend 4 hours on the first section, and 1 hour and 20 minutes on the second section, you could do so. Or, if you want to spend 2 hours and 10 minutes on the first section, and 3 hours and 10 minutes on the second section, you could do that instead. Between sessions, you can take a 25-minute break. (You can take less, if you would like.) You cannot work through the break, and the break time cannot be added to the time permitted for either session. Once each session begins, you can leave your seat for personal reasons, but the "clock" does not stop for your absence. Unanswered questions are scored the same as questions answered incorrectly, so you should use the last few minutes of each session to guess at all unanswered questions.

THE NCEES NONDISCLOSURE AGREEMENT

At the beginning of your CBT experience, a nondisclosure agreement will appear on the screen. In order to begin the exam, you must accept the agreement within two minutes. If you do not accept within two minutes, your CBT experience will end, and you will forfeit your appointment and exam fees. The CBT nondisclosure agreement is discussed in the section entitled "Subversion After the Exam." The nondisclosure agreement, as stated in the November 2013 edition of the *NCEES Examinee Guide*, is as follows.

> This exam is confidential and secure, owned and copyrighted by NCEES and protected by the laws of the United States and elsewhere. It is made available to you, the examinee, solely for valid assessment and licensing purposes. In order to take this exam, you must agree not to disclose, publish, reproduce, or transmit this exam, in whole or in part, in any form or by any means, oral or written, electronic or mechanical, for any purpose, without the prior express written permission of NCEES. This includes agreeing not to post or disclose any test questions or answers from this exam, in whole or in part, on any websites, online forums, or chat rooms, or in any other electronic transmissions, at any time.

YOUR EXAM IS UNIQUE

The exam that you take will not be the exam taken by the person sitting next to you. Differences between exams go beyond mere sequencing differences. NCEES says that the CBT system will randomly select different, but equivalent, questions from its database for each examinee using a linear-on-the-fly (LOFT) algorithm. Each examinee will have a unique exam of equivalent difficulty. That translates into each examinee having a slightly different minimum passing score.

So, you may conclude that either many questions are static clones of others, or that NCEES has an immense database of trusted questions with supporting econometric data.[1,2] However, there is no way to determine exactly how NCEES ensures that each examinee is given an equivalent exam. All that can be said is that looking at your neighbor's monitor would be a waste of time.

THE EXAM INTERFACE

The onscreen exam interface contains only minimal navigational tools. Onscreen navigation is limited to selecting an answer, advancing to the next question, going back to the previous question, and flagging the current question for later review. The interface also includes a timer, the current question number (e.g., 45 of 110), a pop-up scientific calculator, and access to an onscreen version of the *NCEES Handbook*.

During the exam, you can advance sequentially through the questions, but you cannot jump to any specific question, whether or not it has been flagged. After you have completed the last question in a session, however, the navigation capabilities change, and you are permitted to review questions in any sequence and navigate to flagged questions.

THE *NCEES HANDBOOK* INTERFACE

Examinees are provided with a 24-inch computer monitor that will simultaneously display both the exam questions and a searchable PDF of the *NCEES Handbook*. The PDF's table of contents consists of live links. The search function is capable of finding anything in the *NCEES Handbook*, down to and including individual variables. However, the search function finds only precise search terms (e.g., "Hazenwilliams" will not locate "Hazen-Williams"). Like the printed version of the *NCEES Handbook*, the PDF also contains an index, but its terms and phrases are fairly limited and likely to be of little use.

[1]The FE exam draws upon a simple database of finished questions. The CBT system does not construct each examinee's questions from a set of "master" questions using randomly generated values for each question parameter constrained to predetermined ranges.

[2]Questions used in the now-obsolete paper-and-pencil exam were either 2-minute or 4-minute questions, based on the number of questions and time available in morning and afternoon sessions. Since all of the CBT exam questions are 3-minute questions, a logical conclusion is that 100% of the questions are brand new, or (more likely) that morning and afternoon questions are comingled within each subject.

Table 2 *Recommended 8-Week Other Disciplines FE Exam Review Course Format for University Courses*

class	*FE Other Disciplines Review Manual* chapter titles	*FE Other Disciplines Review Manual* chapter numbers
1	Analytic Geometry and Trigonometry; Algebra and Linear Algebra; Calculus; Differential Equations and Transforms; Numerical Methods; Probability and Statistics	1–6
2	Systems of Forces and Moments; Trusses; Pulleys, Cables, and Friction; Centroids and Moments of Inertia; Kinematics; Kinetics; Kinetics of Rotational Motion; Energy and Work; Vibrations	7–15
3	Stresses and Strains; Thermal, Hoop, and Torsional Stress; Beams; Columns; Material Properties and Testing; Engineering Materials	16–21
4	Fluid Properties; Fluid Statics; Fluid Dynamics; Fluid Measurement and Similitude; Compressible Fluid Dynamics; Fluid Machines	22–27
5	Properties of Substances; Laws of Thermodynamics; Power Cycles and Entropy; Mixtures of Gases, Vapors, and Liquids; Combustion; Heat Transfer; Inorganic Chemistry	28–34
6	Electrostatics; Direct-Current Circuits; Alternating-Current Circuits; Amplifiers; Three-Phase Electricity and Power; Computer Software; Measurement and Instrumentation; Signal Theory and Processing; Controls	35–43
7	Safety, Health, and Environment	44
8	Engineering Economics; Professional Practice; Ethics; Licensure	45–48

WHAT IS THE REQUIRED PASSING SCORE?

Scores are based on the total number of questions answered correctly, with no deductions made for questions answered incorrectly. Raw scores may be adjusted slightly, and the adjusted scores are then scaled.

Since each question has four answer choices, the lower bound for a minimum required passing score is the performance generated by random selection, 25%. While it is inevitable that some examinees can score less than 25%, it is more likely that most examinees can score slightly more than 25% simply with judicious guessing and elimination of obvious incorrect options. So, the goal of all examinees should be to increase their scores from 25% to the minimum required passing score.

In the past, NCEES has rarely announced a minimum required passing score for the FE exam, ostensibly because the average score changed slightly with each administration of the exam. However, inside information reports that the raw percentage of questions that must be answered correctly was low—hovering around 50%. NCEES intends to release performance data on the CBT examinations approximately quarterly. That data will probably not include minimum required passing score information.

Since each state requires a passing score of 70, NCEES simply scales 50% (or whatever percentage the minimum required passing score represents) up to 70. Everyone seems happy with this practice—one of the few times that you can get something for nothing.

For the CBT examination, each examinee will have a unique exam of equivalent difficulty. This translates into a different minimum passing score for each examination. NCEES "accumulates" the passing score by summing each question's "required performance value" (RPV).[3] The RPV represents the fraction of minimally qualified examinees that it thinks will solve the question correctly. In the past, RPVs for new questions were dependent on the opinions of experts that it polled with the question, "What fraction of minimally qualified examinees do you think should be able to solve this question correctly?" For questions that have appeared in past exams, including the "pre-test" items that are used on the CBT exam, NCEES actually knows the fraction. Basically, out of all of the examinees who passed the FE exam (the "minimally qualified" part), NCEES knows how many answered a pre-test question correctly (the "fraction of examinees" part). A particularly easy question on Ohm's law might have an RPV of 0.88, while a more difficult question on Bayes' theorem might have an RPV of 0.37. Add up all of the RPVs, and bingo, you have the basis for a passing score. What could be simpler?[4]

WHAT IS THE AVERAGE PASSING RATE?

For the five-year period of 2005 through April 2010, approximately 68% of first-time test takers passed the written discipline-specific Other Disciplines FE exam. The average failure rate was, accordingly, 32%. Some of those who failed the first time retook the FE exam, although the percentage of successful examinees declined precipitously with each subsequent attempt, averaging around 30%.

[3]NCEES does not actually use the term "required performance value," although it does use the method described.

[4]The flaw in this logic, of course, is that water seeks its own level. Deficient educational background and dependency on automation results in lower RPVs, which the NCEES process translates into a lower minimum passing score requirement. In the past, an "equating subtest" (a small number of questions in the exam that were associated with the gold standard of econometric data) was used to adjust the sum of RPVs based on the performance of the candidate pool. Though unmentioned in NCEES literature, that feature may still exist in the CBT exam process. However, the adjustment would still be based on the performance (good or bad) of the examinees.

For the October 2013 administration, 70% of other disciplines first-time examinees passed the FE exam; 32% of repeat test takers passed. These passing rates are higher than normal, and higher than when the FE exam had a different format.

Passing rates for the CBT exam are not yet known.

WHAT REFERENCE MATERIAL CAN I BRING TO THE EXAM?

Since October 1993, the FE exam has been what NCEES calls a "limited-reference exam." This means that nothing except what is supplied by NCEES may be used during the exam. Therefore, the FE exam is really an "NCEES-publication only" exam. NCEES provides its own searchable, electronic version of the *NCEES Handbook* for use during the exam. Computer screens are 24 inches wide so there is enough room to display the exam questions and the *NCEES Handbook* side-by-side. No printed books from any publisher may be used.

WILL THE *NCEES HANDBOOK* HAVE EVERYTHING I NEED DURING THE EXAM?

In addition to not allowing examinees to be responsible for their own references, NCEES also takes no responsibility for the adequacy of coverage of its own reference. Nor does it offer any guidance or provide examples as to what else you should know, study, or memorize. The following warning statement comes from the *NCEES Handbook* preface.

> The *FE Reference Handbook* does not contain all the information required to answer every question on the exam. Basic theories, conversions, formulas, and definitions examinees are expected to know have not been included.

As open-ended as that warning statement sounds, the exam does not actually expect much knowledge outside of what is covered in the *NCEES Handbook*. For all practical purposes, the *NCEES Handbook* will have everything that you need. For example, if the *NCEES Handbook* covers only steel springs, you won't be asked to demonstrate a knowledge of copper-alloy springs. If the *NCEES Handbook* covers only ball and roller bearings, you won't be expected to know about needle or thrust bearings.

That makes it pretty simple to predict the kinds of questions that will appear on the exam. If you take your preparation seriously, the *NCEES Handbook* is pretty much a guarantee that you won't waste any time learning subjects that are not on the FE exam.

WILL THE *NCEES HANDBOOK* HAVE EVERYTHING I NEED TO STUDY FROM?

Saying that you won't need to work outside of the content published in the *NCEES Handbook* is not the same as saying the *NCEES Handbook* is adequate to study from.

From several viewpoints, the *NCEES Handbook* is marginally adequate in organization, presentation, and consistency as an examination reference. The *NCEES Handbook* was never intended to be something you study or learn from, so it is most definitely inadequate for that purpose. Background, preliminary and supporting material, explanations, extensions to the theory, and application rules are all missing from the *NCEES Handbook*. Many subtopics (e.g., contract law) listed in the exam specifications are not represented in the *NCEES Handbook*.

That is why you will notice many equations, figures, and tables in this book that are not blue. You may, for example, read several paragraphs in this book containing various **black** equations before you come across a blue equation section. While the **black** material may be less likely to appear on the exam than the blue material, it provides background information that is essential to understanding the blue material. Although memorization of the **black** material is not generally required, this material should at least make sense to you.

OTHER DISCIPLINES FE EXAM KNOWLEDGE AREAS AND QUESTION DISTRIBUTION

The following Other Disciplines FE exam specifications have been published by NCEES. Some of the topics listed are not covered in any meaningful manner (or at all) by the *NCEES Handbook*. The only conclusion that can be drawn is that the required knowledge of these subjects is shallow, qualitative, and/or nonexistent.

1. **mathematics and advanced engineering mathematics (12–18 questions):** analytic geometry and trigonometry; calculus; differential equations; numerical methods; linear algebra
2. **probability and statistics (6–9 questions):** measures of central tendencies and dispersions; probability distribution; estimation; expected value (weighted average) in decision making; sample distributions and sizes; goodness of fit
3. **chemistry (7–11 questions):** periodic table; oxidation and reduction; acids and bases; equations; gas laws
4. **instrumentation and data acquisition (4–6 questions):** sensors; data acquisition; data processing
5. **ethics and professional practice (3–5 questions):** codes of ethics; NCEES *Model Law*; public protection issues
6. **safety, health, and environment (4–6 questions):** industrial hygiene; basic safety equipment; gas detection and monitoring; electrical safety
7. **engineering economics (7–11 questions):** time value of money; cost; economic analyses; uncertainty; project selection
8. **statics (8–12 questions):** resultants of force systems and vector analysis; concurrent force systems; force couple systems; equilibrium of rigid bodies; frames and trusses; area properties; static friction
9. **dynamics (7–11 questions):** kinematics; linear motion; angular motion; mass moment of inertia; impulse and momentum (linear and angular); work, energy, and power; dynamic friction; vibrations
10. **strength of materials (8–12 questions):** stress types; combined stresses; stress and strain caused by axial loads, bending loads, torsion, or shear; shear and moment diagrams; analysis of beams, trusses, frames, and columns; deflection and deformations; elastic and plastic deformation; failure theory and analysis
11. **materials science (6–9 questions):** physical, mechanical, chemical, and electrical properties of ferrous metals; physical, mechanical, chemical, and electrical properties of nonferrous metals; physical, mechanical, chemical, and electrical properties of engineered materials; corrosion mechanisms and control
12. **fluid mechanics and dynamics of liquids (8–12 questions):** fluid properties; dimensionless numbers; laminar and turbulent flow; fluid statics; energy, impulse, and momentum equations; pipe flow and friction losses; open-channel flow; fluid transport systems; flow measurement; turbomachinery
13. **fluid mechanics and dynamics of gases (4–6 questions):** fluid properties; dimensionless numbers; laminar and turbulent flow; fluid statics; energy, impulse, and momentum equations; duct and pipe flow and friction losses; fluid transport systems; flow measurement; turbomachinery
14. **electricity, power, and magnetism (7–11 questions):** electrical fundamentals; current and voltage laws; DC circuits; equivalent circuits; capacitance and inductance; AC circuits; measuring devices
15. **heat, mass, and energy transfer (9–14 questions):** energy, heat, and work; thermodynamic laws; thermodynamic equilibrium; thermodynamic properties; mixtures of nonreactive gases; heat transfer; mass and energy balances; property and phase diagrams; phase equilibrium and phase change; combustion and combustion products; psychrometrics

DOES THE EXAM REQUIRE LOOKING UP VALUES IN TABLES?

For some questions, you might have to look up a value, but in those cases, you must use the value in the *NCEES Handbook*. For example, you might know that the modulus of elasticity of steel is approximately 29×10^6 psi for soft steel and approximately 30×10^6 psi for hard steel. If

you needed the modulus of elasticity for an elongation calculation, you would find the official *NCEES Handbook* value is "29 Mpsi." Whether or not using 30×10^6 psi will result in an (approximate) correct answer or an incorrect answer depends on whether the question writer wants to reward you for knowing something or punish you for not using the *NCEES Handbook*.

However, in order to reduce the time required to solve questions, and to reduce the variability of answers caused by examinees using different starting values, questions generally provide all required information. Unless the question is specifically determining whether you can read a table or figure, all relevant values (density, modulus of elasticity, viscosity, enthalpy, yield strength, etc.) needed to solve the question are often included in the question statement. NCEES does not want the consequences of using correct methods with ambiguous data.

DO QUESTION STATEMENTS INCLUDE SUPERFLUOUS INFORMATION?

Particularly since all relevant information is provided in the question statements, some questions end up being pretty straightforward. In order to obfuscate the solution method, some irrelevant, superfluous information will be provided in the question statement. For example, when finding the applied force from a given mass and acceleration (i.e., $F = ma$), the temperature and viscosity of the surrounding air might be given. However, if you understand the concept, this practice will be transparent to you.

Questions in this book typically do not include superfluous information. The purpose of this book is to teach you, not confuse you.

REGISTERING FOR THE EXAM

The CBT exams are administered at approved Pearson VUE testing centers. Registration is open year-round and can be completed online through your MyNCEES account.[5] Registration fees may be paid online. Once you receive notification from NCEES that you are eligible to schedule your exam, you can do so online through your MyNCEES account. Select the location where you would like to take your exam, and select from the list of available dates. You will receive a letter from Pearson VUE (via email) confirming your exam location and date.

Whether or not applying for and taking the exam is the same as applying for an FE certificate from your state depends on the state. In most cases, you might take the exam without your state board ever knowing about it. In fact, as part of the NCEES online exam application process, you will have to agree to the following statement:

> Passage of the FE exam alone does not ensure certification as an engineer intern or engineer-in-training in any U.S. state or territory. To obtain certification, you must file an application with an engineering licensing board and meet that board's requirements.

After graduation, when you are ready to obtain your FE (EIT, IE, etc.) suitable-for-wall-hanging certificate, you can apply and pay an additional fee to your state. In some cases, you will be required to take an additional nontechnical exam related to professional practice in your state. Actual procedures will vary from state to state.

WINDOWS OF OPPORTUNITY

The FE exam is administered in eight months out of the year: January, February, April, May, July, August, October, and November. There are multiple testing dates within each of those months. No exams are administered in March, June, September, or December.

WHAT TO BRING TO THE EXAM

You do not need to bring much with you to the exam. For admission, you must bring a current, signed, government-issued photographic identification. This is typically a driver's license or passport. A student ID card is not acceptable for admittance. The first and last name on the photographic ID must match the name on your appointment confirmation letter. NCEES recommends that you bring a copy of your appointment confirmation letter in order to speed up the check in process. In most cases, Pearson VUE will email this to you, or you can download it from your MyNCEES account, 2–3 weeks prior to the exam date.

Earplugs, noise-cancelling headphones, and tissues are provided at the testing center for examinees who request them. Additionally, all examinees are provided with a reusable, erasable notepad and compatible writing instrument to use for scratchwork during the exam.

Pearson VUE staff may visually examine any approved item without touching you or the item. In addition to the items provided at the testing center, the following items are permitted during the FE exam.[6]

- your ID (same one used for admittance to the exam)
- key to your test center locker
- NCEES-approved calculator without a case

[5]PPI is not associated with NCEES. Your MyNCEES account is not your PPI account.

[6]All items are subject to revision and reinterpretation at any time.

- inhalers
- cough drops and prescription and nonprescription pills, including headache remedies, all unwrapped and not bottled, unless the packaging states they must remain in the packaging
- bandages, braces (for your neck, back, wrist, leg, or ankle), casts, and slings
- eyeglasses (without cases); eye patches; handheld, nonelectric magnifying glasses (without cases); and eyedrops[7]
- hearing aids
- medical/surgical face masks, medical devices attached to your body (e.g., insulin pumps and spinal cord stimulators), and medical alert bracelets (including those with USB ports)
- pillows and cushions
- light sweaters or jackets
- canes, crutches, motorized scooters and chairs, walkers, and wheelchairs

WHAT ELSE TO BRING TO THE EXAM

Depending on your situation, any of the following items may prove useful but should be left in your test center locker.

- calculator batteries
- contact lens wetting solution
- spare calculator
- spare reading glasses
- loose shoes or slippers
- extra set of car keys
- eyeglass repair kit, including a small screwdriver for fixing glasses (or removing batteries from your calculator)

WHAT NOT TO BRING TO THE EXAM

Leave all of these items in your car or at home: pens and pencils, erasers, scratch paper, clocks and timers, unapproved calculators, cell phones, pagers, communication devices, computers, tablets, cameras, audio recorders, and video recorders.

WHAT CALCULATORS ARE PERMITTED?

To prevent unauthorized transcription and distribution of the exam questions, calculators with communicating and text editing capabilities have been banned by NCEES. You may love the reverse Polish notation of your HP 48GX, but you'll have to get used to one of the calculators NCEES has approved. If you start using one of these approved calculators at the beginning of your review, you should be familiar enough with it by the time of the exam.

Calculators permitted by NCEES are listed at **ppi2pass.com/calculators**. All of the listed calculators have sufficient engineering/scientific functionality for the exam.

At the beginning of your review program, you should purchase or borrow a spare calculator. It is preferable, but not essential, that your primary and spare calculators be identical. If your spare calculator is not identical to your primary calculator, spend some time familiarizing yourself with its functions.

Examinees found using a calculator that is not approved by NCEES will be discharged from the testing center and charged with exam subversion by their states. (See section "Exam Subversion.")

WHAT UNITS ARE USED ON THE EXAM?

You will need to learn the SI system if you are not already familiar with it. Contrary to engineering practice in the United States, the FE exam primarily uses SI units.

The *NCEES Handbook* generally presents only dimensionally consistent equations. (For example, $F = ma$ is consistent with units of newtons, kilograms, meters, and seconds. However, it is not consistent for units of pounds-force, pounds-mass, feet, and seconds.) Although pound-based data is provided parallel to the SI data in most tables, many equations cannot use the pound-based data without including the gravitational constant. After being mentioned in the first few pages, the gravitational constant ($g_c = 32.2$ ft-lbm/lbf-sec^2), which is necessary to use for equations with inconsistent U.S. units, is barely mentioned in the *NCEES Handbook* and does not appear in most equations.

Outside of the table of conversions and introductory material at its beginning, the *NCEES Handbook* does not consistently differentiate between pounds-mass and pounds-force. The labels "pound" and "lb" are used to represent both force and mass. Densities are listed in tables with units of lb/in^3.

Kips are always units of force that can be incorporated into ft-kips, units for moment, and ksi, units of stress or strength.

IS THE EXAM HARD AND/OR TRICKY?

Whether or not the exam is hard or tricky depends on who you talk to. Other than providing superfluous data (so as not to lead you too quickly to the correct formula) and anticipating common mistakes, the FE exam is not

[7]Eyedrops can remain in their original bottle.

a tricky exam. The exam does not overtly try to get you to fail. The questions are difficult in their own right. NCEES does not need to provide you misleading or vague statements. Examinees manage to fail on a regular basis with perfectly straightforward questions.

Commonly made mistakes are routinely incorporated into the available answer choices. Thus, the alternative answers (known as distractors) will seem logical to many examinees. For example, if you forget to convert the pipe diameter from millimeters to meters, you'll find an answer option that is off by a factor of 1000. Perhaps, that meets your definition of "tricky."

Questions are generally practical, dealing with common and plausible situations that you might encounter on the job. In order to avoid the complications of being too practical, the ideal or perfect case is often explicitly called for in the question statement (e.g., "Assume an ideal gas."; "Disregard the effects of air friction."; or "The steam expansion is isentropic.").

You won't have to draw on any experiential knowledge or make reasonable assumptions. If a motor efficiency is required, it will be given to you. You won't have to assume a reasonable value. If a beam is to be sized to limit distressing architectural deflections, the limit will be explicitly given to you. If an allowable stress requires a factor of safety, the factor of safety will be given to you.

IS THE EXAM SOPHISTICATED?

Considering the features available with computerized testing, the sophistication of the FE testing algorithm is relatively low. All of the questions are fixed and predefined; new questions are not generated from generic stubs. You will get the same number of questions in each knowledge area, regardless of how well or poorly you do on previous questions in that knowledge area; adaptive testing is not used. The testing software randomly selects questions from a limited database; it is possible to see some of the same questions if you take the exam a second time.

Only two levels of categorization are used in the database: discipline and knowledge area. For example, a problem would be categorized as "Other Disciplines" and "Statics." With questions randomly selected from the database, the variation (breadth) of coverage follows the variation of the database. Within the limitations imposed by the need for an equivalent exam, it is statistically possible for the testing program to present you with twelve cantilever beam questions or eighteen differential equation questions.

Although the overall difficulty level of the exam is intended to be equivalent for all examinees, the difficulty level within a particular knowledge area can vary significantly. For example, within the Probability and Statistics knowledge area, you might have to solve nine Bayes' Theorem questions, while your friend may get nine coin flip problems. In order to keep the overall difficulty level the same, after calculating all of those conditional probabilities, you may be rewarded with nine simple $F = ma$ and $v = Q/A$ type problems, while your friend gets to work problems involving organic chemistry, entropy, and three-dimensional tripods.

GOOD-FAITH EFFORT

Let's be honest. Some examinees take the FE exam because they have to, not because they want to. This situation is usually associated with university degree programs that require taking the exam as a condition of graduation. In most cases, such programs require only that students take the exam, not pass it. Accordingly, some short-sighted students consider the exam to be a formality, and they give it only token attention.

NCEES uses several methods to determine if you have made a "good-faith effort" on the exam. Some of the criteria for determining that you haven't include marking all of the answer choices the same (all "A," all "B," etc.), using a repeating sequence of responses (e.g., "A, B, C, D" over and over), leaving the exam site significantly early, and achieving a raw score of less than 30%. These criteria may be used by themselves or together.

The test results of examinees who are deemed not to have given a "good-faith effort" are separated statistically from other test results. Releasing to the universities the names of specific examinees whose test results are in that category is at the discretion of NCEES, which has not yet formalized its policy.

WHAT DOES "MOST NEARLY" REALLY MEAN?

One of the more disquieting aspects of exam questions is that answer choices generally have only two or three significant digits, and the answer choices are seldom exact. An exam question may prompt you to complete the sentence, "The value is most nearly...", or may ask "Which answer choice is closest to the correct value?" 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.

At one time, NCEES provided this statement regarding the use of "most nearly."

> 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 all these answers that have been derived correctly but which 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 flow rate of pure water required to dilute a contaminated stream to an acceptable concentration. Suppose, also, that you calculated 823 gpm. If the answer choices were (A) 600 gpm, (B) 800 gpm, (C) 1000 gpm, and (D) 1200 gpm, you would go with answer choice (B), because it is most nearly what you calculated. If, however, you were asked to select a pump or pipe to provide the calculated capacities, you would have to go with choice (C). Got it? If not, stop reading until you understand the distinction.

WHEN DO I FIND OUT IF I PASSED?

You will receive an email notification that your exam results are ready for viewing through your MyNCEES account 7 10 days after the exam. That email will also include instructions that you can use to proceed with your state licensing board. If you fail, you will be shown your percentage performance in each knowledge area. The diagnostic report may help you figure out what to study before taking the exam again. Because each examinee answers different questions in each knowledge area, the diagnostic report probably should not be used to compare the performance of two examinees, to determine how much smarter than another examinee you are, to rate employees, or to calculate raises and bonus.

If you fail the exam, you may take it again. NCEES's policy is that examinees may take the exam once per testing window, up to three times per 12-month period. However, you should check with your state board to see whether it imposes any restrictions on the number and frequency of retakes.

SUBVERSION DURING THE EXAM

With the CBT exam, you can no longer get kicked out of the exam room for not closing your booklet or putting down your pencil in time. However, there are still plenty of ways for you to run afoul of the rules imposed on you by NCEES, your state board, and Pearson VUE. For example, since communication devices are prohibited in the exam, occurrences as innocent as your cell phone ringing during the exam can result in the immediate invalidation of your exam.

The November 2013 *NCEES Examinee Guide* gives the following statement regarding fraudulent and/or unprofessional behavior. Somewhere along the way, you will probably have to read and accept it, or something similar, before you can take the FE exam.

> Fraud, deceit, dishonesty, unprofessional behavior, and other irregular behavior in connection with taking any NCEES exam are strictly prohibited. Irregular behavior includes but is not limited to the following: failing to work independently; impersonating another individual or permitting such impersonation (surrogate testing); possessing prohibited items; communicating with other examinees or any outside parties by way of cell phone, personal computer, the Internet, or any other means during an exam; disrupting other examinees; creating safety concerns; and possessing, reproducing, or disclosing nonpublic exam questions, answers, or other information regarding the content of the exam before, during, or after the exam administration. Evidence of an exam irregularity may be based on your performance on the exam, a report from an administrator or a third party, or other information.
>
> The test administrator is authorized to take appropriate action to investigate, stop, or correct any observed or suspected irregular behavior, including discharging you from the test center and confiscating prohibited devices or materials. You must cooperate fully in any investigation of a suspected irregularity. NCEES reserves the right to pursue all available remedies for exam irregularities, including canceling scores and pursuing administrative, civil, and/or criminal remedies.
>
> If you are involved in an exam irregularity, the following may occur: invalidation of results, notification to your licensing board, forfeiture of exam fees, and restrictions on future testing. Some violations may incur additional consequences, to be pursued at the discretion of NCEES.

Based on the grounds for dismissal used for the paper-and-pencil exam up through 2013, you can expect harsh treatment for

- having a cell phone in your possession
- having a device with copying, recording, or communication capabilities in your possession. These include but are not limited to cameras, pagers, personal digital assistants (PDAs), radios, headsets, tape players, calculator watches, electronic dictionaries, electronic translators, transmitting devices, digital media players (e.g., iPods), and tablets (e.g., iPads, Kindles, or Nooks)
- having papers, books, or notes
- having a calculator that is not on the NCEES-approved list
- appearing to or copying someone else's work
- talking to another examinee during the exam

- taking notes or writing on anything other than your NCEES-provided reusable, erasable notepad
- removing anything from the exam area
- leaving the exam area without authorization
- violating any other restrictions that are cause for dismissal or exam invalidation (e.g., whistling while you work, chewing gum, or being intoxicated)

If you are found to be in possession of a prohibited item (e.g., a cell phone) after the exam begins, that item will be confiscated and sent to NCEES. While you will probably eventually get your cell phone back, you won't get a refund of your exam fees.

Cheating and what is described as "subversion" are dealt with quite harshly. Proctors who observe you giving or receiving assistance, compromising the integrity of the exam, or participating in any other form of cheating during an exam will require you to surrender all exam materials and leave the test center. You won't be permitted to continue with the exam. It will be a summary execution, carried out without due process and mercy.

Of course, if you arrive with a miniature camera disguised as a pen or eyeglasses, your goose will be cooked. Talk to an adjacent examinee, and your goose will be cooked. Use a mirror to look around the room while putting on your lipstick or combing your hair, and your goose will be cooked. Bring in the wrong calculator, and your goose will be cooked. Loan your calculator to someone whose batteries have died, and your goose will be cooked. Though you get the idea, many of the ways that you might inadvertently get kicked out of the CBT exam are probably (and, unfortunately) yet to be discovered. Based on this fact, you shouldn't plan on being the first person to bring a peppermint candy in a crackly cellophane wrapper.

And, as if being escorted with your personal items out of the exam room wasn't embarrassing enough, your ordeal still won't be over. NCEES and your state will bar you from taking any exam for one or more years. Any application for licensure pending an approval for exam will be automatically rejected. You will have to reapply and pay your fees again later. By that time, you probably will have decided that the establishment's response to a minor infraction was so out of proportion that licensure as a professional engineer isn't even in the cards.

SUBVERSION AFTER THE EXAM

The NCEES testing (and financial) model is based on reusing all of its questions forever. To facilitate such reuse, the FE (and PE) exams are protected by nondisclosure agreements and a history of aggressive pursuit of actual and perceived offenses. In order to be allowed to take its exams, NCEES requires examinees to agree to its terms.

Copyright protection extends to only the exact words, phrases, and sentences, and sequences thereof, used in questions. However, the intent of the NCEES nondisclosure agreement is to grant NCEES protection beyond what is normally available through copyright protection—to prevent you from even discussing a question in general terms (e.g., "There was a question on structural bolts that stumped me. Did anyone else think the question was unsolvable?").

Most past transgressions have been fairly egregious.[8] In several prominent instances, NCEES has incurred substantial losses and expenses. In those cases, offenders have gotten what they deserved. But, even innocent public disclosures of the nature of "Hey, did anyone else have trouble solving that vertical crest curve question?" have been aggressively pursued.

A restriction against saying anything at all to anybody about any aspect of a question is probably too broad to be legally enforceable. Unfortunately, most examinees don't have the time, financial resources, or sophistication to resist what NCEES throws at them. Their only course of action is to accept whatever punishment is meted out to them by their state boards and by NCEES.

In the past, NCEES has used the U.S courts and aggressively pursued financial redress for loss of its intellectual property and violation of its copyright. It has administratively established a standard (accounting) value of thousands of dollars for each disclosed or compromised question. You can calculate your own *pro forma* invoice from NCEES by multiplying this amount by the number of questions you discuss with others.

DOING YOUR PART, NCEES STYLE

NCEES has established a security tip line so that you can help it police the behavior of other examinees. Before, during, or after the exam, if you see any of your fellow examinees acting suspiciously, NCEES wants you to report them by phone or through the NCEES website. You'll have to identify yourself, but NCEES promises that the information you provide will be strictly confidential, and that your personal contact information will not be shared outside the NCEES compliance and security staff. Unless required by statute, rules of discovery, or a judge, of course.

[8] A candidate in Puerto Rico during the October 2006 Civil PE exam administration was found with scanning and transmitting equipment during the exam. She had recorded the entire exam, as well as the 2005 FE exam. The candidate pled guilty to two counts of fourth-degree aggravated fraud and was sentenced to six months' probation. All of the questions in both exams were compromised. NCEES obtained a civil judgment of over $1,000,000 against her.

PART 4: STRATEGIES FOR PASSING THE EXAM

A FEW DAYS BEFORE THE EXAM

There are a few things you should do a week or so before the examination date. For example, visit the exam site in order to find the testing center building, parking areas, examination room, and restrooms. You should also make arrangements for childcare and transportation. Since your examination may not start or end exactly at the designated times, make sure that your childcare and transportation arrangements can allow for some flexibility.

Second in importance to your scholastic preparation is the preparation of your two examination kits. (See "What to Bring to the Exam" and "What Else to Bring to the Exam" in this Introduction.) The first kit includes items that can be left in your assigned locker (e.g., your admittance letter, photo ID, and extra calculator batteries). The second kit includes items that should be left in your car in case you need them (e.g., copy of your application, warm sweater, and extra snacks or beverages).

THE DAY BEFORE THE EXAM

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

Make sure your exam kits are packed and ready to go.

THE DAY OF THE EXAM

You should arrive at least 30 minutes before your scheduled start time. This will allow time for finding a convenient parking place, bringing your items to the testing center, and checking in.

DURING THE EXAM

Once the examination has started, observe the following suggestions.

Do not spend more than four minutes working a problem. (The average time available per problem is slightly less than three minutes.) If you have not finished a question in that time, flag it for later review if you have time, and continue on.

Don't ask your proctors technical questions. Proctors are pure administrators. They don't know anything about the exam or its subjects.

Even if you do not discover them, errors in the exam (and in the *NCEES Handbook*) do occur. Rest assured that errors are almost always discovered during the scoring process, and that you will receive the performance credit for all flawed items.

However, NCEES has a form for reporting errors, and the test center should be able to provide it to you. If you encounter a problem with (a) missing information, (b) conflicting information, (c) no correct response from the four answer choices, or (d) more than one correct answer, use your provided reusable, erasable notepad to record the problem identification numbers. It is not necessary to tell your proctor during the exam. Wait until after the exam to ask your proctor about the procedure for reporting errors on the exam.

AFTER YOU PASS

- [ ] Celebrate. Take someone out to dinner. Go off your diet. Get dessert.
- [ ] Thank your family members and anyone who had to put up with your grouchiness before the exam.
- [ ] Thank your old professors.
- [ ] Tell everyone at the office.
- [ ] Ask your employer for new business cards and a raise.
- [ ] Tell your review course provider and instructors.
- [ ] Tell the folks at PPI who were rootin' for you all along.
- [ ] Start thinking about the PE exam.

Sample Study Schedule (for Individuals)

Time required to complete study schedule:

62 days for a "crash course," going straight through, with no rest and review days, no weekends, and no final exam
80 days going straight through, taking off rest and review days, but no weekends
93 days using only the five-day work week, taking off rest and review days, and weekends

Your examination date: _____

Number of days: _____

Latest day you can start: _____

day no	date	chap. no.	knowledge area	subject
1	_____	Introduction	Mathematics and Advanced Engineering Mathematics	Introduction; Units; Diagnostic Exam
2	_____	1		Analytic Geometry and Trigonometry
3	_____	2		Algebra and Linear Algebra
4	_____	3		Calculus
5	_____	none		**rest; review**
6	_____	4		Differential Equations and Transforms
7	_____	5		Numerical Methods
8	_____	II	Probability and Statistics	Diagnostic Exam
9	_____	6		Probability and Statistics
10	_____	none		**rest; review**
11	_____	III	Statics	Diagnostic Exam
12	_____	7		Systems of Forces and Moments
13	_____	8		Trusses
14	_____	9		Pulleys, Cables, and Friction
15	_____	10		Centroids and Moments of Inertia
16	_____	none		**rest; review**
17	_____	IV	Dynamics	Diagnostic Exam
18	_____	11		Kinematics
19	_____	12		Kinetics
20	_____	13		Kinetics of Rotational Motion
21	_____	14		Energy and Work
22	_____	15		Vibrations
23	_____	none		**rest; review**
24	_____	V	Strength of Materials	Diagnostic Exam
25	_____	16		Stresses and Strains
26	_____	17		Thermal, Hoop, and Torsional Stress
27	_____	18		Beams
28	_____	19		Columns
29	_____	none		**rest; review**
30	_____	VI	Materials Science	Diagnostic Exam
31	_____	20		Material Properties and Testing
32	_____	21		Engineering Materials
33	_____	none		**rest; review**
34	_____	VII	Fluid Mechanics and Dynamics of Gases and Liquids	Diagnostic Exam
35	_____	22		Fluid Properties
36	_____	23		Fluid Statics
37	_____	24		Fluid Dynamics
38	_____	25		Fluid Measurement and Similitude
39	_____	26		Compressible Fluid Dynamics
40	_____	27		Fluid Machines
41	_____	none		**rest; review**

day no	date	chap. no.	knowledge area	subject
42	_____	VIII	Heat, Mass, and Energy Transfer	Diagnostic Exam
43	_____	28		Properties of Substances
44	_____	29		Laws of Thermodynamics
45	_____	30		Power Cycles and Entropy
46	_____	31		Mixtures of Gases, Vapors, and Liquids
47	_____	32		Combustion
48	_____	33		Heat Transfer
49	_____	none		**rest; review**
50	_____	IX	Chemistry	Diagnostic Exam
51	_____	34		Inorganic Chemistry
52	_____	X	Electricity, Power, and Magnetism	Diagnostic Exam
53	_____	35		Electrostatics
54	_____	36		Direct-Current Circuits
55	_____	37		Alternating-Current Circuits
56	_____	38		Amplifiers
57	_____	39		Three-Phase Electricity and Power
58	_____	none		**rest; review**
59	_____	XI	Instrumentation and Data Acquisition	Diagnostic Exam
60	_____	40		Computer Software
61	_____	41		Measurement and Instrumentation
62	_____	42		Signal Theory and Processing
63	_____	43		Controls
64	_____	none		**rest; review**
65	_____	XII	Safety, Health, and Environment	Diagnostic Exam
66	_____	44		Safety, Health, and Environment
67	_____	XIII	Engineering Economics	Diagnostic Exam
68	_____	45		Engineering Economics
69	_____	none		**rest; review**
70	_____	XIV	Ethics and Professional Practice	Diagnostic Exam
71	_____	46		Professional Practice
72	_____	47		Ethics
73	_____	48		Licensure
74	_____	none		**rest; review**
75–79	_____	none	none	Practice Exam
80	_____	none		FE Examination