Introduction

PART 1: HOW YOU CAN USE THIS BOOK

The Quickstart

If you never read the material at the front of your books anyway, if you are in a hurry to begin, and you 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. Do not stop studying until the exam. Start right now! Quickly! Good luck.

The Quickstart, Augmented

While the Quickstart will, as its name implies, get you started quickly, you may be looking for a more detailed “How to Use This Book.” (I certainly would if I were taking the most important exam of my engineering career!) So, if you want to begin a thorough review, you should first try to find out everything there is to know about the National Council of Examiners for Engineering and Surveying (NCEES) PE Civil exam.

I’ve included important information about the exam in this Introduction, but it alone won’t be enough. This is why the second thing I recommend you do is to figure out how to make your review realistic. In the exam, you must be able to recall solution procedures, formulas, and important data quickly. 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 is not much different from preparing for a big game. Some part of your preparation should be realistic and representative of the exam environment.

There are several things you can do to make your review more realistic. For example, if you gather most of your review resources 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 for information you need. 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.

Third, in addition to reading this Introduction, I highly recommend you visit PPI’s online PE Resource Center. This resource is chock full of answers to questions like “I’m a practicing engineer, and it’s been a while since I’ve studied for an exam. What do I do?” Or, “How much mathematics is needed for the exam?” Or, even the broad question of “Help! What should I study?” You can get answers to these questions and more by going to the PE Resource Center on PPI’s website.

Finally, many of the tables and appendices in this book are representative abridgments with just enough data to do the practice problems in the companion book and give you a false sense of security. You can download or link to additional data, explanations, and references by visiting PPI’s website.

If you are an Instructor

If you are an instructor and have obtained this book in order to teach a class on how to pass the PE Civil exam, you’ll also want to review PPI’s instructor resources. Access instructor resources by visiting PPI’s website.

Now let’s get started!

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

What is the Format of the PE Civil Exam?

The NCEES PE exam in civil engineering consists of two four-hour sessions separated by a one-hour lunch period. The breadth session is taken by all examinees. There are five depth modules: construction, geotechnical, structural, transportation, and water resources and environmental. (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 “MyNCEES” system on the NCEES website. You select your depth module when you register for the exam. At the exam, you will receive an exam 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 breadth and depth 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.

**What Subjects Are On the PE Civil Exam?**

NCEES has published a description of subjects on the exam. Irrespective of the published exam 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 consider a pump selection question to come from the subject of fluids, while NCEES might categorize it as engineering economics.

A detailed analysis of topics covered on the PE Civil exam is given in Table 1.

The problem counts in Table 1 are according to NCEES, but these problem counts are approximate. NCEES adds,

> The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application. Some problems may require knowledge of engineering economics. The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.

**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 design a structure for reduced gravity on the moon, to design a mud-brick road, to analyze the effects of a nuclear bomb blast on a structure, or to use bamboo for tension reinforcement.

**Does the Exam Use SI Units?**

The PE civil exam primarily uses customary U.S. units although SI and a variety of other metric systems are also used. Questions use the units that correspond to commonly accepted industry standards. Structural problems use customary U.S. units exclusively. Some questions, such as those in structural, soils, surveying, and traffic subjects, primarily use units of pounds, feet, seconds, gallons, and degrees Fahrenheit.

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, although the use of metric units is still rare.

Unlike this book, the exam does not differentiate between lbf (pounds-force) and lbm (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, $g_c$.

**How Is the Exam Graded and Scored?**

The maximum number of points you can earn on the civil 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 do not. 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 exam from your state board (not NCEES) online through your MyNCEES account or by mail, depending on your state. 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.

Your score may or may not be revealed to you, depending on your state’s procedure. Even if the score is reported to you, it may have been scaled or normalized to 100%. It may be difficult to determine whether the reported score is out of 80 points or is out of 100%.
Table 1 Detailed Analysis of Tested Subject

MORNING SESSION

(40 multiple-choice questions)*

Project planning (4): quantity take-off methods; cost estimating; project schedules; activity identification and sequencing

Means and methods (3): construction loads; construction methods; temporary structures and facilities

Soil mechanics (6): lateral earth pressure; soil consolidation; effective and total stresses; bearing capacity; foundation settlement; slope stability

Structural mechanics (6): dead and live loads; trusses; bending (e.g., moments and stresses); shear (e.g., forces and stresses); axial (e.g., forces and stresses); combined stresses; deflection; beams; columns; slabs; footings; retaining walls

Hydraulics and hydrology (7): open-channel flow; stormwater collection and drainage (e.g., culvert, stormwater inlets, gutter flow, street flow, storm sewer pipes); storm characteristics (e.g., storm frequency, rainfall measurement, and distribution); runoff analysis (e.g., rational and SCS/NRCS methods, hydrographic application, runoff time of concentration); detention/retention ponds; pressure conduit (e.g., single pipe, force mains, Hazen-Williams, Darcy-Weisbach, major and minor losses); energy and/or continuity equation (e.g., Bernoulli)

Geometrics (3): basic circular curve elements (e.g., middle ordinate, length, chord, radius); basic vertical curve elements; traffic volume (e.g., vehicle mix, flow, and speed)

Materials (6): soil classification and boring log interpretations; soil properties (e.g., strength, permeability, compressibility, phase relationships); concrete (e.g., nonreinforced, reinforced); structural steel; material test methods and specification conformance; compaction

Site development (5): excavation and embankment (e.g., cut and fill); construction site layout and control; temporary and permanent soil erosion and sediment control (e.g., construction erosion control and permits, sediment transport, channel/outlet protection); impact of construction on adjacent facilities; safety (e.g., construction, roadside, work zone)

AFTERNOON SESSIONS

(40 multiple-choice questions)*

CIVIL/CONSTRUCTION DEPTH EXAM

Earthwork construction and layout (6): excavation and embankment (e.g., cut and fill); borrow pit volumes; site layout and control; earthwork mass diagrams and haul distance; site and subsurface investigations

Estimating quantities and costs (6): quantity take-off methods; cost estimating; cost analysis for resource selection; work measurement and productivity

Construction operations and methods (7): lifting and rigging; crane stability; dewatering and pumping; equipment operations (e.g., selection, production, economics); deep foundation installation

Scheduling (5): construction sequencing; activity time analysis; critical path method (CPM) network analysis; resource scheduling and leveling; time-cost trade-off

Material quality control and production (6): material properties and testing (e.g., soils, concrete, asphalt); weld and bolt installation; quality control process (QA/QC); concrete proportioning and placement; concrete maturity and early strength evaluation

Temporary structures (7): construction loads, codes, and standards; formwork; falsework and scaffolding; shoring and reshoring; bracing and anchorage for stability; temporary support of excavation

Health and safety (3): OSHA regulations and hazard identification/abatement; safety management and statistics; work zone and public safety

CIVIL/GEOTECHNICAL DEPTH EXAM

Site characterization (5): interpretation of available existing site data and proposed site development data (e.g., aerial photography, geologic and topographic maps, GIS data, as-built plans, planning studies and reports); subsurface exploration planning; geophysics (e.g., GPR, resistivity, seismic methods); drilling techniques (e.g., hollow stem auger, cased boring, mud rotary, air rotary, rock coring, sonic drilling); sampling techniques (e.g., split-barrel sampling, thin-walled tube sampling, handling and storage); in situ testing (e.g., standard penetration testing, cone penetration testing, pressure meter testing, dilatometer testing, field vane shear); description and classification of soils (e.g., Burmeister, Unified Soil Classification System, AASHTO, USDA); rock classification and characterization (e.g., recovery, rock quality designation, RMR, weathering, orientation); groundwater exploration, sampling, and characterization

Soil mechanics, laboratory testing, and analysis (5): index properties and testing; strength testing of soil and rock; stress-strain testing of soil and rock; permeability testing properties of soil and rock; effective and total stresses

Field materials testing, methods, and safety (3): excavation and embankment, borrow source studies, laboratory and field compaction; trench and construction safety; geotechnical instrumentation (e.g., inclinometer, settlement plates, piezometer, vibration monitoring)

Earthquake engineering and dynamic loads (2): liquefaction analysis and mitigation techniques; seismic site characterization, including site classification using ASCE7; pseudo-static analysis and earthquake loads
Earth structures (4): slab on grade; ground improvement (e.g., grouting, soil mixing, preconsolidation/wicks, lightweight materials); geosynthetic applications (e.g., separation, strength, filtration, drainage, reinforced soil slopes, internal stability of MSE); slope stability and slope stabilization; earth dams, levees, and embankments; landfills and caps (e.g., interface stability, drainage systems, lining systems); pavement structures (rigid, flexible, or unpaved), including equivalent single-axle load (ESAL), pavement thickness, subgrade testing, subgrade preparation, maintenance and rehabilitation treatments; settlement

Groundwater and seepage (3): seepage analysis/groundwater flow; dewatering design, methods, and impact on nearby structures; drainage design/infiltration; grouting and other methods of reducing seepage

Problematic soil and rock conditions (3): Karst; collapsible, expansive, and sensitive soils; reactive/corrosive soils; frost susceptibility

Earth retaining structures (ASD or LRFD) (5): lateral earth pressure; load distribution; rigid retaining wall stability analysis (e.g., CIP, gravity, external stability of MSE, crib, bin); flexible retaining wall stability analysis (e.g., soldier pile and lagging, sheet pile, secant pile, tangent pile, diaphragm walls, temporary support of excavation, braced and anchored walls); cofferdams; underpinning (e.g., effects on adjacent construction); ground anchors, tie-backs, soil nails, and rock anchors for foundations and slopes

Shallow foundations (ASD or LRFD) (5): bearing capacity; settlement, including vertical stress distribution

Deep foundations (ASD or LRFD) (5): single-element axial capacity (e.g., driven pile, drilled shaft, micropile, helical screw piles, auger cast piles); lateral load and deformation analysis; single-element settlement; downdrag; group effects (e.g., axial capacity, settlement, lateral deflection); installation methods/hammer selection; pile dynamics (e.g., wave equation, high-strain dynamic testing, signal matching); pile and drilled-shaft load testing; integrity testing methods (e.g., low-strain impact integrity testing, ultrasonic cross-hole testing, coring, thermal integrity testing)

CIVIL/STRUCTURAL DEPTH EXAM

Analysis of Structures (14)

Loads and load applications (4): dead loads; live loads; construction loads; wind loads; seismic loads; moving loads (e.g., vehicular, cranes); snow, rain, ice; impact loads; earth pressure and surcharge loads; load paths (e.g., lateral and vertical); load combinations; tributary areas

Forces and load effects (10): diagrams (e.g., shear and moment); axial (e.g., tension and compression); shear; flexure; deflection; special topics (e.g., torsion, buckling, fatigue, progressive collapse, thermal deformation, bearing)

Design and Details of Structures (20)

Materials and material properties (5): concrete (e.g., plain, reinforced, cast-in-place, precast, pre-tensioned, post-tensioned); steel (e.g., structural, reinforcing, cold-formed); timber; masonry (e.g., brick veneer, CMU)

Component design and detailing (15): horizontal members (e.g., beams, slabs, diaphragms); vertical members (e.g., columns, bearing walls, shear walls); systems (e.g., trusses, braces, frames, composite construction); connections (e.g., bearing, bolted, welded, embedded, anchored); foundations (e.g., retaining walls, footings, combined footings, slabs, mats, piers, piles, caissons, drilled shafts)

Codes and Construction (6)

Codes, standards, and guidance documents (4): International Building Code (IBC); American Concrete Institute (ACI 318, 530); Precast/Prestressed Concrete Institute (PCI Design Handbook) (ACI 530/530.1); Steel Construction Manual (AISC); National Design Specification for Wood Construction (NDS); LRFD Bridge Design Specifications (AASHTO); Minimum Design Loads for Buildings and Other Structures (ASCE7); American Welding Society—Steel (AWS D1.1, D1.2, and D1.4); Structural Welding Code—Aluminum (AWS D1.2); Structural Welding Code—Reinforcing Steel (AWS D1.4); OSHA 1910; General Industry and OSHA 1926 Construction Safety Standards

Temporary structures and other topics (2): special inspections; submittals; formwork; falsework and scaffolding; shoring and reshoring; concrete maturity and early strength evaluation; bracing; anchorage; OSHA regulations; safety management

CIVIL/TRANSPORTATION DEPTH EXAM

Traffic engineering (capacity analysis and transportation planning) (11): uninterrupted flow (e.g., level of service, capacity); street segment interrupted flow (e.g., level of service, running time, travel speed); intersection capacity (e.g., at grade, signalized, roundabout, interchange); traffic analysis (e.g., volume studies, peak hour factor, speed studies, modal split); trip generation and traffic impact studies; accident analysis (e.g., conflict analysis, accident rates, collision diagrams); nonmotorized facilities (e.g., pedestrian, bicycle); traffic forecast; highway safety analysis (e.g., crash modification factors, Highway Safety Manual)

Horizontal design (4): basic curve elements (e.g., middle ordinate, length, chord, radius); sight distance considerations; superelevation (e.g., rate, transitions, method, components); special horizontal curves (e.g., compound/reverse curves, curve widening, coordination with vertical geometry)

Vertical design (4): vertical curve geometry; stopping and passing sight distance (e.g., crest curve, sag curve); vertical clearance

Intersection geometry (4): intersection sight distance; interchanges (e.g., freeway merge, entrance and exit design, horizontal design, vertical design); at-grade intersection layout, including roundabouts

P P i e  p p i 2 p a s s . c o m
Roadside and cross-section design (4): forgiving roadside concepts (e.g., clear zone, recoverable slopes, roadside obstacles); barrier design (e.g., barrier types, end treatments, crash cushions); cross-section elements (e.g., lane widths, shoulders, bicycle lane, sidewalks); Americans with Disabilities Act (ADA) design considerations

Signal design (3): signal timing (e.g., clearance intervals, phasing, pedestrian crossing timing, railroad preemption); signal warrants

Traffic control design (3): signs and pavement markings; temporary traffic control

Geotechnical and pavement (4): sampling and testing (e.g., subgrade resilient modulus, CBR, R-values, field tests); soil stabilization techniques, settlement and compaction, excavation, embankment, and mass balance; design traffic analysis and pavement design procedures (e.g., flexible and rigid pavement); pavement evaluation and maintenance measures (e.g., skid, roughness, structural capacity, reliability treatments)

Drainage (2): hydrology (e.g., rational method, hydrographs, SCS/NRCS method), including runoff detention/retention/water quality mitigation measures; hydraulics, including culvert and stormwater collection system design (e.g., inlet capacities, pipe flow, hydraulic energy dissipation), and open-channel flow

Alternatives analysis (1): economic analysis (e.g., present worth, lifecycle costs)

CIVIL/WATER RESOURCES AND ENVIRONMENTAL DEPTH EXAM

Analysis and design (4): mass balance; hydraulic loading; solids loading (e.g., sediment loading, sludge); hydraulic flow measurement

Hydraulics—closed conduit (5): energy and/or continuity equation (e.g., Bernoulli, momentum equation); pressure conduit (e.g., single pipe, force mains, Hazen-Williams, Darcy-Weisbach, major and minor losses); pump application and analysis, including wet wells, lift stations, and cavitation; pipe network analysis (e.g., series, parallel, and loop networks)

Hydraulics—open channel (5): open-channel flow; hydraulic energy dissipation; stormwater collection and drainage (e.g., culvert, stormwater inlets, gutter flow, street flow, storm sewer pipes); subcritical and supercritical flow

Hydrology (7): storm characteristics (e.g., storm frequency, rainfall measurement, and distribution); runoff analysis (e.g., rational and SCS/NRCS methods); hydrograph development and applications, including synthetic hydrographs; rainfall intensity, duration, and frequency; time of concentration; rainfall and stream gauging stations; depletions (e.g., evaporation, detention, percolation, and diversions); stormwater management (e.g., detention ponds, retention ponds, infiltration systems, and swales)

Groundwater and wells (3): aquifers; groundwater flow; well analysis—steady state

Wastewater collection and treatment (6): wastewater collection systems (e.g., lift stations, sewer networks, infiltration, inflow, smoke testing, maintenance, and odor control); wastewater treatment processes; wastewater flow rates; preliminary treatment; primary treatment; secondary treatment (e.g., physical, chemical, and biological processes); nitrification/denitrification; phosphorus removal; solids treatment, handling, and disposal; digestion; disinfection; advanced treatment (e.g., physical, chemical, and biological processes)

Water quality (3): stream degradation; oxygen dynamics; total maximum daily load (TMDL) (e.g., nutrient contamination, DO, load allocation); biological contaminants; chemical contaminants, including bioaccumulation

Drinking water distribution and treatment (6): drinking water distribution systems; drinking water treatment processes; demands; storage; sedimentation; taste and odor control; rapid mixing (e.g., coagulation); flocculation; filtration; disinfection, including disinfection byproducts; hardness and softening

Engineering economics analysis (1): economic analysis (e.g., present worth, lifecycle costs, comparison of alternatives)

*The numbers in parentheses reflect the approximate number of questions for a given exam topic.
How is the Cut Score Established?

The raw cut score may be 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 individual 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 equate questions) and any flawed problems. Rarely, security breaches result in compromised problems or exams. How equate questions, exam flaws, and security issues affect examinee performance is not released by NCEES to the public.

What is the Historical Passing Rate?

Within a few percentage points, 60-70% of first-time exam takers pass the civil engineering PE exam. The passing rate for repeat exam takers is less than half of the first-time exam taker passing rate.

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.

Cheating and Exam Subversion

There are not 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 should not use your cell phone. The number of people who are released to use the restroom may be limited to prevent discussions.

NCEES regularly reuses problems that have appeared on previous exams. Therefore, exam 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 the 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 exam problems, as well as invalidating any engineering license you may have earned by taking one of its exams while engaging in prohibited activities. Your state board may impose additional restrictions on your right to retake any exam if you are convicted of such activities. In addition to tracking down the sources of any exam problem compilations that it becomes aware of, NCEES is also aggressive in pursuing and prosecuting examinees who disclose the contents of the exam in online forum 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 exam. If you wish to participate in a dialogue 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 exam and reframing the question to avoid any exam particulars.

The proctors are concerned about exam subversion, which generally means activity that might invalidate the exam 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 exam invalidated, and all of your pleas and arguments in favor of 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 exam cycles. There is no mercy built in to the NCEES and state board procedures.

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 exam question. Other people need lots of quiet space, and prefer just to 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 is 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.

**PART 3: ALL ABOUT THE MULTIPLE-CHOICE QUESTIONS**

Now that you know the logistics about the PE Civil exam, it’s time to break down the essential information about the questions.

**What Is the Typical Question Format?**

All of the questions are stand-alone—that is, they are completely independent. 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 correct.

Since the questions are multiple-choice in design, all required data will appear in the situation statement. Since the exam 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. 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 do not find an exact match for the answer you calculated, or if you have had to split the difference because no available answer option is close.

NCEES has described 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 water flow required to dilute a contaminated stream to an acceptable concentration. Suppose, also, that you calculated 823 gpm. If the answer options were (A) 600 gpm, (B) 800 gpm, (C) 1000 gpm, and (D) 1200 gpm, you would go with answer option (B), because it is most nearly what you calculated. If, however, you were asked to select a pump or pipe with the same rated capacities, you would have to go with option (C) because an 800 gpm pump would not be sufficient. Got it?

**How to Solve Multiple-Choice Problems**

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 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 question for which you cannot find a correct response, that appears to have two correct responses, or that you believe has 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 exam, 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.
Many points are lost to carelessness. Keep the following items in mind when you are solving practice problems. Hopefully, these suggestions will be automatic in the exam.

[ ] Did you recheck your mathematical equations?
[ ] Do the units 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 between kPa and Pa?
[ ] 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?)

How You Should Guess

There is no deduction for incorrect answers, so guessing is encouraged. However, since NCEES produces defensible 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 distractors 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, you go back to random guessing. That is the reason that the minimum passing score is higher than 25%.

You will not get any points using the “test-taking skills” that helped you in college. You will not be able to eliminate any [verb] answer choices from “Which [noun] …” questions. You will not find problems with options of the “more than 50” and “less than 50” variety. You will not 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.

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. Many highway capacity questions are this way. Some questions are difficult because the data needed is hard to find. Some data just is not available unless you happen to have brought the right reference book. Many of the structural questions are of this nature. There is no way to solve most structural steel questions without the AISC Manual. Designing an eccentrically loaded concrete column without published interaction diagrams is nearly impossible to do in six minutes. If you did not bring OSHA regulations to the exam, you are not going to be able to answer many safety questions.

Some questions are difficult because they defy the imagination. Three-dimensional structural questions and some surveying curve questions fit this description. If you cannot visualize the question, you probably cannot solve it.

Some questions are difficult because the computational burden is high, and they just take a long time. Pipe networking questions solved with the Hardy Cross method fall into this category.

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

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.

Why Does NCEES Reuse Some Questions?

NCEES reuses some of the more reliable questions from each exam. The percentage of repeat questions is not 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 water chemistry, timber, masonry, 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 should not be used as the basis of your review.
What About the Example Problems In This Book?

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.

How About Mathematics, Economics, and Ethics?

Mathematics

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 higher-order equations.

For second-order (quadratic) equations, NCEES does not care if you find roots by factoring, completing the square, using the quadratic equation, 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 exist.

There is essentially no use of calculus on the exam. Rarely, you may need to take a simple derivative to find a maximum or minimum of some simple algebraic function. Even rarer is the need to integrate to find an average, moment of inertia, statical moment, or shear flow.

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 typically 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 will not have to use 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. Although the term “least squares” may appear in surveying 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. However, elements of simple queuing theory are integrated into some traffic and transportation subjects, so you should have a basic familiarity with the terminology of queues.

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.

Engineering Economics

For most of the early years of engineering licensing, questions on engineering economics appeared frequently on the exams. This is no longer the case. However, in its outline of exam subjects, NCEES notes: “Some questions may require knowledge of engineering economics.” This means that engineering economics might appear in several questions on the exam, or the subject might be totally absent. While the degree of engineering economics knowledge may have decreased somewhat, the basic economic concepts (e.g., time value of money, present worth, nonannual 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 do not even mention “dollars” (e.g., when you need to predict future water demand, population growth, or traffic volume).

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. Construction engineering questions dealing with obligations related to contracts, bidding, estimating, inspection, and regulations sometimes get pretty close to the subject of professional practice. However, you will not encounter the phrase “ethical obligation” in the exam.
PART 4: EXAM DAY PREPARATION

As you get closer to your exam date, you may have questions like: “What reference materials are permitted in the exam? What should you study? How many books should you bring on exam day? Is there an exam day checklist I can use to make sure I don’t forget anything?” To answer these questions and more, PPI has prepared a comprehensive resource What to Bring to the PE Exam. It is available in the PE Resource Center on PPI’s website. PPI’s Preparing for the PE Exam: A Checklist is another resource to help get you thinking about items you’ll want to bring to the exam (as well as some worse-case scenarios to plan for). You can find it in the PE Resource Center on PPI’s website.

While the bulk of great “how to’s,” checklists, and exam day suggestions are provided in the previously mentioned resources, I would be remiss as the author of this book, and also as a fellow engineer, if I didn’t leave you with at least one simple planning suggestion. So here it is.

A Simple Planning Suggestion

As you go about your review, designate some location (a drawer, a corner, a cardboard box, or even a paper shopping bag left on the floor) as your “exam catchall.” Use your catchall 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 soil pressure questions. Or, you might decide that a certain book is particularly valuable, 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 is not actually necessary to put these treasured items in the catchall during your preparation. You can, of course, if it is 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 catchall. 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.

You should also create for yourself a study schedule. An interactive, adjustable, and personalized study schedule is available when you subscribe to PPI’s Learning Hub.

PART 5: POST-EXAM THOUGHTS

By the time you have “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 will be the “expert,” and I will be your biggest fan.

And Then Finally, 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 would not 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 was not 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 examination 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 examination 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: Grading is not merely a matter of putting your examination booklet and answer sheet in an electronic reader. All of these steps have to be completed for 100% of the examinees before any results can be delivered.

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 examinees who did not pass 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 do not list much of anything on their websites. Some states send you back to your MyNCEES account to see your results. Regardless of the how, the wait remains. It will be up to you to figure out a way to distract yourself until you hear you find out whether you passed.

And When You Pass...

[ ] Celebrate.
[ ] Notify the people who wrote letters of recommendation or reference for you.
[ ] Ask your employer for a raise.
[ ] Tell the folks at PPI (who have been rootin’ for you all along) the good news.