# Introduction

## HOW TO USE THIS BOOK

This book serves multiple purposes.

First, as the title suggests, it is intended to serve as a comprehensive reference for practicing surveyors. If you are a practicing surveyor, you will find it to be an invaluable and frequently used addition to your library.

Second, because of its comprehensive coverage, it is an ideal resource for people preparing for the Fundamentals of Surveying (FS) exam. (It is also an ideal textbook for instructors teaching review courses for the FS exam.) This book may also be used as a study aid for the Principles and Practice of Surveying (PS) exam, but since it is intended as a comprehensive manual of fundamental principles rather than an in-depth analysis of any particular area of surveying, it may not be suitable as a stand-alone study guide for all portions of the PS.

## THE FS AND PS EXAMS

The FS and PS exams are standardized tests prepared by the National Council of Examiners for Engineering and Surveying (NCEES) to ensure that only qualified people are legally allowed to practice as surveyors. To ensure the reliability and validity of the tests, the FS and PS exams are based on input from committees of professional surveyors and educators throughout the United States.

The FS exam tests general entry-level surveying principles you are expected to have gained through academic study. In most states, passing the FS exam is a requirement for registration as a surveyor-in-training or surveyor intern. The PS exam tests your ability to apply those principles to the kinds of problems typically encountered in professional practice. Passing the PS exam is required in most states for full licensure as a professional surveyor. This may be necessary if your company requires licensure for employment or advancement, or if your state requires registration before you may use the title “Surveyor,” if you wish to be an independent consultant, or for other reasons. The PS exam is usually administered in conjunction with an exam on surveying practices and regulations specific to the state administering the exam.

Although both the FS and PS exams are prepared by NCEES, they are administered under the direction of the licensing boards of the various states, which usually also require you to have attained a certain level of education and (for the PS exam) experience before taking the exams. For information regarding these requirements in the state in which you plan to become licensed, and to apply for licensure, contact that state’s board. Current addresses and phone numbers for each state board may be obtained at PPI’s website, ppi2pass.com.

## THE FS EXAM

### Structure

The FS exam is a computer-based test that concentrates on the fundamentals and basics of surveying. You may take it at any Pearson VUE test center.

The exam contains 110 problems. Only one problem is given on screen at a time. The exam is not adaptive (i.e., your response to one problem has no bearing on the next problem you are given); even if you answer the first five mathematics problems correctly, you’ll still have to answer the sixth problem.

Your exam will include a limited (and unknown) number of problems that will not be scored and will not have an impact on your results (known as “pretest items”). NCEES does this to evaluate potential problems for future exams. You won’t know which problems are pretest items. They are not identifiable and are randomly distributed throughout the exam.

The FS exam is 6 hours long and includes an 8-minute tutorial, a 25-minute break, and 2 minutes to sign a non-disclosure agreement. The total time you’ll have to answer the exam problems is 5 hours and 20 minutes, which works out to slightly less than 3 minutes per problem. However, the exam does not pace you. You may spend as much time as you like on each question. You may take less than a 25-minute break, if you like, but you cannot work through the break, and the break time cannot be added to the time you have to complete your exam. You may also leave your seat for personal reasons, but the “clock” does not stop for your absence.

You may work through the problems in any sequence. If you want to go back and check your answers before you submit them for grading, you may. However, once you submit your answers, you are not able to go back and review them. Unanswered problems are scored the same as problems answered incorrectly, so you should use the last few minutes of your exam time to guess at all unanswered problems.
The NCEES Nondisclosure Agreement
At the beginning of the FS exam, a nondisclosure agreement will appear on the screen. To begin the exam, you must accept the agreement within two minutes. If you do not accept within two minutes, your exam appointment will end, and you will forfeit your appointment and exam fees. The nondisclosure agreement is discussed in the section titled “Subversion After the Exam.” The nondisclosure agreement, as stated in 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. 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 exactly the same exam taken by the person sitting next to you. NCEES says that, for each examinee, its computer-based testing (CBT) system randomly selects different but equivalent problems from its database using a linear, on-the-fly (LOFT) algorithm. Each examinee will have a unique exam, and all exams will be of equivalent difficulty.

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

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

Knowledge Areas and Problem Distribution
The FS exam includes problems in 13 knowledge areas. Each area is listed as follows, with the number of problems relating to this area that you can expect to see on your exam and a list of topics included in this area.

1. **Mathematics (13–20 problems):** algebra, trigonometry, and basic geometry; spherical trigonometry; linear algebra and matrix theory; analytic geometry and calculus
2. **Basic sciences (5–8 problems):** geology, dendrology, cartography, and environmental sciences
3. **Spatial data acquisition and reduction (6–9 problems):** vertical measurement, distance measurement, angle measurement, unit conversions, redundancy, knowledge and utilization of instruments and methods, and understanding of historical methods and instruments.
4. **Survey computations and computer applications (19–29 problems):** coordinate geometry, traverse closure and adjustment, area, volume, horizontal and vertical curves, spirals, and spreadsheets
5. **Statistics and adjustments (6–9 problems):** mean, median, and mode; variance and standard deviation; error analysis; least squares adjustment; measurement and positional tolerance; and relative, network, and positional accuracy
6. **Geodesy (5–8 problems):** basic theory, satellite positioning, gravity, coordinate systems, datums, and map projections
7. **Boundary and cadastral survey law (13–20 problems):** controlling elements, gathering and identifying evidence, records research, legal descriptions, case law, riparian rights, public land survey system, metes and bounds, simultaneously created parcels, easements and encumbrances
8. **Photogrammetry and remote sensing (4–6 problems):** interpretation and analysis, project and flight planning, quality control, ground control, and LiDAR
9. **Survey processes and methods (11–17 problems):** land development (principles, standards, and regulations); boundary location; mapping, cartography, and topography; construction; riparian surveys; route surveying; and control surveys
10. **Geographic information systems (GIS) (5–8 problems):** feature collection and integration, database concepts and design, accuracy and use, and metadata
11. **Graphical communication and mapping (6–9 problems):** plans and specifications; contours and slopes; scales; planimetric features and symbols; land forms; digital terrain modeling and digital
elevation modeling; and survey maps, plats, drawings, and reports.

12. Professional communication (4–6 problems): oral and written communication; alternative forms of communication; documentation and record-keeping.

13. Business concepts (3–5 problems): contracts, liability and risk management, financial practices, leadership and management principles, personnel management principles, project planning and design; ethics; and safety.

Exam content is subject to change. Consult PPI’s website (ppi2pass.com) for current specifications.

THE PS EXAM

Structure

The PS exam is also a computer-based, closed-book exam. There are 100 problems on the exam. A PS testing session is 7 hours long, which includes 2 minutes for completion of a nondisclosure agreement, 8 minutes for a tutorial, and 6 hours for actually taking the exam. The exam is divided into two sections, each with approximately 50 problems, and an optional 50-minute scheduled break between the sections.

Knowledge Areas and Problem Distribution

The PS exam includes problems in five knowledge areas. Those areas are listed here with their subtopics and the number of problems to expect in each knowledge area.

1. Legal principles (18–27 problems)
   Principles of Evidence: how to search for data and for physical evidence to evaluate data; how to evaluate data; parol evidence; prescriptive rights; adverse possession; acquiescence; controlling elements; easement rights
   Common Law Boundary Principles: historical and current common law principles; riparian and littoral rights; sovereign rights, including both navigable waters and eminent domain; sovereign land grants
   Sequential and Simultaneous Conveyance Concepts: types of conveyances; junior/senior rights; record and physical evidence
   Legal Descriptions for Real Property Transactions: preparation and interpretation of legal descriptions; controlling elements and how they impact the description; unwritten rights and how they impact the description; encumbrances and how they impact the description; easements and how they impact the description.
   Evidence for the Perpetuation of the U.S. PLSS

2. Professional survey practices (22–33 problems)
   Public/Private Record Sources: resources for private and public records; local public records indexing and filing system; local survey office records
   Documentation, Supervision, and Clear Communication of Field Procedures: field surveying techniques; field surveying practices; data collection protocols
   GPS/GNSS Including Satellite Constellations, Static GPS, RTK, PPP, and Virtual Networks
   Surveying Principles and Computations: technical computations; applicable software
   Monumentation Standards: applicable monumentation criteria; monument types
   Land Development Solutions: regulatory land development criteria; construction criteria; land development implementation procedures
   Survey Maps/Plats/Reports: technical communications by schematic, platting, and mapping processes and procedures; communication options
   GIS: GIS spatial databases and metadata; datums and projections related to GIS

3. Standards and specifications (8–12 problems)
   BLM Manual of Surveying Instructions
   ALTA/NSPS Land Title Survey Standards: current ALTA/NSPS Land Title Survey Standards; state statutes regarding boundary surveys in conjunction with ALTA/NSPS Land Title Surveys
   FEMA Requirements: FEMA specifications and instructions; horizontal and vertical datums related to FEMA flood zones; current FEMA elevation certificate; FEMA Flood Insurance Study

4. Business practices (13–19 problems)
   General Business Practices and Procedures: project planning and project management; deliverables; costs, budgets, and contracts; types of surveys; site features and conditions; scope of services; appropriate equipment and instruments
   Risk Management Procedures: safety procedures; QA/QC methods; risk management in contracts; insurance needs and requirements; potential liabilities
   Professional Conduct
   Communication with Clients, Staff, Related Professions, and the Public: different forms of communications; appropriate type of communication to convey concepts; related professions and their impact on client needs and deliverables

5. Areas of practice (24–36 problems)
   ALTA/NSPS Land Title Surveys: legal documents, such as deeds, easements, and agreements; zoning information as applied to ALTA/NSPS Land Title Surveys;
title insurance commitment letters and policies; underground features as applied to ALTA/NSPS Land Title Surveys

Control Networks and Geodetic Network Surveys: datums and reference frames relative to control networks; differences between local datums and geodetic datums; equipment appropriate for control surveys; the Federal Geographic Data Committee Geospatial Positioning Accuracy Standards; the National Geospatial Programs (NGP) Standards and Specifications—Digital Data Standards

Construction Surveys: construction plan reading; construction calculations including slopes, grades, and plan details; construction techniques and activities; horizontal and vertical positioning relative to a plan or datum

Boundary Surveys: physical boundary evidence; boundary reconciliations; historical measurement accuracy, equipment, and techniques; legal principles related to boundary surveys

Route Surveys for Alignments and Utilities: route alignment stationing practices; reading and interpreting roadway and utility plans

Topographic: topographic/planimetric mapping and control standards; interpretation, reconciliation, and adjustment of topographic survey data; QA/QC procedures as applied to topographic surveys; ground, hydrographic, and remote sensing equipment; the U.S. National Map Accuracy Standards as applied to topographic surveys; tools and techniques required to perform hydrographic, bathymetric, and remote sensing surveys; nomenclature related to utilities

Surveys to Establish New Parcels, Lots, or Units: types of subdivisions; plating; condominiums and associations; deed restrictions and restrictive covenants; zoning and subdivision ordinances

As-Built/Record Drawing Surveys: as-built/record drawing calculations including slopes, grades, and plan details; as-built/record drawing techniques and activities; horizontal and vertical as-built/record drawing positions relative to a plan or datum

Consultation Services: site topography and slope for development purposes; site access for development purposes; zoning standards related to new projects; floodplains as related to land development

Note: Exam content is subject to change. Consult PPI’s website (ppi2pass.com) for current specifications.

TYPICAL PROBLEM FORMAT FOR THE FS AND PS EXAMS

The multiple-choice problems on the FS exam are typically short, straightforward, and designed to test your knowledge of the fundamentals of surveying and mapping.

The PS exam is designed to test your ability to apply surveying fundamentals to typical problems encountered in surveying practice. For example, a series of land descriptions from deeds might be provided, followed by problems requiring you to analyze the descriptions, establish certain boundaries or corner positions, and treat encroachments.

Most of the problems in both exams will be in the traditional multiple-choice exam, with a problem statement followed by four answer options. But, with the new CBT format, the exams may include alternative item type (AIT) problems, such as multiple correct problems, fill-in-the-blank problems, point-and-click (on points on a graphic) problems, and drag-and-drop problems for ranking or labeling items.

Both the FS and PS exams test in customary U.S. units. Therefore, the majority of this book also utilizes U.S. units. However, in some cases where SI units are commonly used in practice, SI units (or dual units) are given. For a complete list of unit conversions, see Apps. A, B, and C.

EXAM SCORING

Neither the FS exam nor the PS exam is graded on a curve, since a certain minimum competency must be demonstrated to safeguard the public welfare. Nevertheless, the tests may vary slightly in difficulty, depending upon the problems selected for a particular exam. Therefore, problems are reviewed by committees of practicing surveyors before the exams. These committees evaluate the difficulty of each problem in order to develop a “standard of minimum competency,” or recommended passing score for each exam. However, the individual state boards have the authority to determine the passing score in their respective states. Credit is given for each correct answer, and no points are deducted for incorrect answers.

USE OF CALCULATORS AND COMPUTERS IN THE EXAMS

The exams require use of a scientific calculator. However, it may not be obvious that you should also bring a spare calculator with you. It would be unfortunate not to be able to finish because your calculator was dropped or stolen or stopped working for some unknown reason.

NCEES has banned communicating and text-editing calculators from the exam site. Only select types of calculators are permitted. Check the current list of permissible devices at PPI’s website (ppi2pass.com). All the listed calculators have enough functionality for the exam.

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

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

Laptop computers are not permitted in the exam. You may not use a walkie-talkie, cell phone, or other communications device during the exam.

THE NCEES REFERENCE HANDBOOKS

Both the FS and PS exam are “closed book.” No references may be used except for either the FS Reference Handbook or PS Reference Handbook, as appropriate. Your Handbook will be made available in computer format on a split-screen, to allow viewing of the exam problems together with a searchable version of the Handbook. The search function can find only precise terms (e.g., searching for “non-annual compounding” will not locate “nonannual compounding”).

Whichever exam you are preparing for, you should download a copy of the appropriate reference handbook from the NCEES website and use it in your studies. Become familiar with its contents and organization so that during the exam you can find equations and tables quickly when you need them. You may download and print out either handbook for your personal use, but you may not take your personal copy to the exam.

The PS Reference Handbook contains the following statement.

The Handbook does not contain all the information required to answer every question on the exam. Some of the basic theories, conversions, formulas, and definitions examinees are expected to know have not been included in the supplied references. When appropriate, NCEES will provide information in the question statement itself to assist you in solving the problem.

Some basic formulas and conversion factors not in the handbooks may be needed to finish the exam. As a result, to be well prepared, you should know many of the basic formulas for both exams.

CHEATING AND EXAM SUBVERSION

The proctors are well trained to ensure that cheating does not occur. Obviously, you should not talk to other examinees during the exam, nor should you pass notes back and forth. To prevent discussion, the number of people permitted to use the restrooms at the same time will typically be limited.

The NCEES regularly reuses good problems from previous exams. Therefore, exam security is a serious issue with NCEES, which goes to great lengths to prevent copying of problems. You may not copy the problems in any manner.

The proctors are especially concerned about exam subversion, which generally means any activity that might invalidate the exam or the exam process. The most common form of exam subversion involves trying to copy exam problems for future use.

PREPARING FOR YOUR EXAM

Plan Your Approach

You should consider preparation for the FS or PS exam to be a long-term project and plan carefully. The exams are both comprehensive and fast paced; rapid recall, discipline, stamina, and mastery of the subject areas covered are all essential to success. Development of these qualities may require months of preparation in addition to the years of academic study and work practice you needed to qualify. Therefore, it is important to plan your preparation for the exam as you would plan for a large surveying and mapping project.

These steps can help prepare you.

1. Review the list of subject areas earlier in this Introduction to gain insight into the nature and content of the exams.
2. Answer the practice problems at the end of each chapter of this book.
3. For future reference, prepare a concise outline as you work through each area.
4. Your review should be on a rigorous schedule as you work through each chapter. Tab pages where frequently used or hard-to-find information is located. Consider taking continuing education courses in problem areas.
5. For any areas in which you are not comfortable, read additional reference material as you work through each chapter. Tab pages where frequently used or hard-to-find information is located. Consider taking continuing education courses in problem areas.
6. Take a practice exam, such as the Fundamentals of Surveying Practice Exam or Principles and Practice of Surveying Practice Exam (both available from PPI), to evaluate your readiness for the exams.
7. Work on any weak areas revealed by the practice exam.
8. Conduct a final review of your notes.
Learning to use your time wisely is one of the most important things that you can do during your review. You will undoubtedly encounter review problems that take much longer than you expect. You may cause some delays yourself by spending too much time looking through the Handbook for the information you need. Other problems will just entail too much work. Learning to recognize such situations more quickly will help you make intelligent decisions during the exams.

**Additional Reference Material**

You will find that this book is an excellent starting point for preparing for your exam. However, additional references may be helpful, especially in areas in which you are uncomfortable. There are countless available texts that cover the various topics in depth. Listed here are several personal favorites that offer coverage of the areas to be tested on the exams. Edition numbers have been omitted since new editions are often issued. Use the most recent edition available.

**Legal Principles**


**Measurement and Computation Theory and Practice**


**Geographic Information Systems and Photogrammetry**


**Land Development**


**Practice Problems**


**Last-Minute Preparation**

A week or so before your exam, conduct an intensive review of the outlines you prepared during your study. Arrange for child care and transportation since the exam does not always start or end at the designated time, make sure such arrangements are flexible. If convenient, visit the exam site ahead of time to locate the building, parking areas, exam rooms, and restrooms.

Take a backup calculator to your exam. If your spare calculator is not the same type as your primary one, spend some time familiarizing yourself with it. Make sure that you have correct replacement batteries for both calculators. In addition, you should prepare a kit of items to take to the exam.

Take the day before the exam off from work to relax. If you live far from the exam site, consider getting a hotel room in which to spend the night. Do not attempt to cram the night before the exam. Calculate your wake-up time, and set two alarms. Select and lay out your clothing and breakfast items, and make sure that you have gas in your car and money in your wallet.

**TAKING YOUR EXAM**

**What to Take to Your Exam**

Your exam kit should contain items you need, such as your photo ID and your calculator, as well as items pertaining to your personal comfort. However, you may bring only certain items into the testing room, and the list of permitted items is different for the FS and PS exams.

You will need your photo ID in order to be admitted to the test site for either exam. Your ID must be government issued and must include:

- your name
- your date of birth
- a recognizable photo of you
- your signature (except for U.S. military IDs)
- an expiration date (not past)
Your exam kit might contain the following items. Some of these, however, you may not bring into the testing room and must leave in a small locker that will be provided to you. You may access the locker during the break between sessions, but not during either session.

- an acceptable form of photo ID (essential)
- a printed copy of your appointment confirmation letter (strongly recommended)
- your primary calculator, with fresh batteries installed
- your backup calculator (left in locker)
- spare batteries for both calculators (left in locker)
- eyeglasses (case left in locker)
- eyeglasses repair kit, including a small screwdriver for fixing glasses or removing batteries from your calculator (left in locker)
- contact lens wetting solution (left in locker)
- a light sweater or jacket (pockets empty)
- cough drops (unwrapped and not in a bottle or container; a clear plastic bag is acceptable)

• aspirin or other pills (unwrapped and not in a bottle or container; a clear plastic bag is acceptable)
• eyedrops
• a pillow or cushion (if you need one in order to sit comfortably through the exam)
• several dollars in loose change (left in locker)
• an extra set of car keys (left in locker)
• something to eat during the break (left in locker)

You will be provided with earplugs, noise-cancelling headphones, tissues, and a reusable booklet and marker for scratch work, so you don’t have to bring your own; if you do, you will not be permitted to bring them into the testing room. You must leave your wallet, purse, wristwatch, car keys, cell phone, and other personal items in your locker.

You may also bring essential medicines, medical devices, and mobility devices. These items will be inspected visually before you may bring them into the testing room. These include

- bandages
- braces (neck, back, wrist, leg, or ankle)
- canes
- crutches
- casts, slings, and other injury-related items that cannot be removed

- eye patches
- handheld magnifying glasses (not electronic; case left in locker)
- hearing aids or cochlear implants
- inhalers
- insulin pumps (or other medical devices attached to your body)
- medical alert bracelets
- medical/surgical face masks
- motorized scooters or chairs
- oxygen tanks
- walkers
- wheelchairs

For medical-related items not on this list, you must get approval in advance of your exam day.

What to Do at the Exam

Arrive at least 30 minutes before your exam is scheduled to begin. This will allow you to find a convenient parking place, get to the exam room, and calm down. Be prepared, though, to find that the exam room is not open or ready at the designated time.

On both the FS and PS exams, every problem is worth the same number of points, so it is a good idea to answer all of the problems that you can within a reasonable amount of time before attempting to solve problems that will take a disproportionate amount of time. If time allows, you can go back to those difficult problems.

Many points are lost due to carelessness. Therefore, it is a good idea to read each problem twice before solving. Check to make sure that you used all of the given data and done the appropriate conversion of units. While the exam problems are not tricky, you may find the results of commonly made mistakes are represented among the available answer choices. Thus, just because there is an answer matching your results does not mean that you have obtained the correct results.

Credit is given for correct answers, but no credit is deducted for wrong answers. Therefore, it is in your best interest to answer every question. It is a good idea to use the last ten minutes of the exam to guess at any remaining unsolved multiple-choice problems. You will be successful with about 25% of your guesses, and those points will more than make up for the few points you might earn by working during the last ten minutes.

After Your Exam

People react quite differently to the exam experience. Some people are energized and need to unwind by talking with other examinees, describing every detail of
their experience and dissecting every exam problem. However, most people are completely exhausted and need a lot of quiet space and a hot tub in which to soak and sulk. 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. It is difficult not to ask how someone else approached a problem that had you completely stumped. However, it is also very disquieting to think you did well on a problem, only to have someone else tell you where you went wrong.

Waiting for your exam results is its own form of mental torture. There is no predictable pattern to the release of the results. Exam results are not released by NCEES to all states simultaneously. They are not released alphabetically by state or examinee name. The people who failed are not notified first or last. Your co-worker might receive their notification today, and you might have to wait another three weeks. It all depends on when the entire process is complete. Some states have to have the results approved at a board meeting. Some prepare certificates before sending out notifications. Some states are more highly automated than others. The number of examinees also varies by state, as do numerous other factors. Therefore, you just have to wait patiently.

You will typically receive your results within 7 to 10 days. Your licensing board will contact you with your results. If you passed the exam, you will receive a letter that states you passed. If you failed, you will receive notice of this and get a diagnostic report that shows your strengths and weaknesses.

Now that you know all there is to know about the exams and about how to prepare for them, the rest is up to you. Plan your approach, and get to work. The very best of luck to you!