
Introduction

ABOUT THE SAMPLE EXAM

The sample examination in this book is designed to simulate the National Council of Examiners for Engineering and Surveying (NCEES) Fundamentals of Surveying (FS) examination in subject matter, level of difficulty, length, and question type. The realistic review it provides will allow you to evaluate your level of preparedness, and will make you familiar with the examination process. If you can comfortably pass this sample exam, you should be able to pass the actual exam.

At the beginning of each session of the sample exam, there are pages of reference formulas and conversion factors. This information is similar to the reference material that NCEES will provide as part of the actual exam. As on the actual exam, it may be helpful to know other formulas and factors to complete the sample exam.

Throughout the sample exam, all azimuths are measured clockwise from north.

The biggest difference between this sample exam and the actual exam is that, here, solutions are provided for each sample problem. After you take the sample exam, the solutions will help you check your approach.

ABOUT THE ACTUAL EXAM

In most of the United States, requirements for registration as a surveyor include the NCEES FS exam and, later, the NCEES Principles and Practice of Surveying exam. In many states, the FS exam is a requirement for the Surveyor-In-Training or Surveying Intern registration.

Exam Format

The FS exam is an eight-hour examination concentrating on basic principles of surveying and the application of mathematical formulas to the solution of surveying problems. The test consists of two four-hour sections, separated by a one-hour break. Each of the two portions of the examination contains 85 questions. For each question, you will be asked to select the best answer from four choices. Examination books and mechanical pencils are provided for recording answers, which are

scored by machine. No credit is deducted for wrong answers. Therefore, it is in your best interest to answer each question.

Exam Content

The FS examination includes problems in 15 knowledge areas. These areas are listed here, along with a list of typical surveying activities in each area that might be addressed in the exam. Also provided is the percentage of examination questions that can be expected in each area. The information is from NCEES.

I. Algebra and Trigonometry (11%)

This area includes units of measurement; formula development; formula manipulation; solving systems of equations; basic mensuration formulas for length, area, and volume; quadratic equations; trigonometric functions; right triangle solutions; oblique triangle solutions; spherical triangle solutions; and trigonometric identities.

- Perform astronomic measurements.
- Perform trigonometric and differential leveling.
- Compute survey data.
- Compute areas and volumes.
- Determine and prepare lot and street patterns for land division.
- Design horizontal and vertical alignment for roads within a subdivision.

II. Higher Math (Beyond Trigonometry) (4%)

This area includes analytical geometry; linear algebra; equations of a line, circle, parabola, and ellipse; differentiation of functions; integration of elementary functions; infinite series; and mathematical modeling.

- Perform geodetic surveys using conventional methods.
- Perform geodetic and plane surveys using GPS methods.
- Perform astronomic measurements.
- Compute, analyze, and adjust survey data.
- Design horizontal and vertical alignment for roads within a subdivision.

III. Probability and Statistics, Measurement Analysis, and Data Adjustment (5%)

This area includes standard deviation; variance; standard deviation of unit weight; tests of significance; concept of probability and confidence intervals; error ellipses; data distributions and histograms; analysis of error sources; error propagation; control network analysis; blunder trapping and elimination; least squares adjustment; calculation of uncertainty of position; accuracy standards; and analysis of historical measurements.

- Determine levels of precision and order of accuracy.
- Perform geodetic and plane surveys using conventional or GPS methods.
- Compute, analyze, and adjust survey data.
- Determine levels of precision and order of accuracy.
- Perform astronomic measurements.
- Perform record or as-built surveys.
- Perform ALTA/ACSM, hydrographic, photogrammetric control, boundary, route and right-of-way, topographic, flood plain, construction, and condominium surveys.
- Perform trigonometric and differential leveling.
- Produce survey data using photogrammetric methods.
- Reconcile survey and record data.
- Convert survey data to an appropriate datum.
- Prepare work sheets for analysis of surveys.
- Determine locations of boundary lines and encumbrances.
- Determine and prepare lot and street patterns for land division.
- Design horizontal and vertical alignment for roads within a subdivision.
- Develop and provide data for LIS/GIS.

IV. Basic Sciences (4%)

This area includes light and wave propagation; basic electricity; optics; gravity; refraction; mechanics; forces; kinematics; temperature and heat; biology; dendrology; geology; and plant science.

- Calibrate instruments.

V. Geodesy, Survey Astronomy, and Geodetic Survey Calculation (6%)

This area includes reference ellipsoids; gravity fields; geoid; geodetic datums; direction and distance on the

ellipsoid; conversion from geodetic heights to elevation; orbit determination and tracking; determination of azimuth using common celestial bodies; time systems; calculation of position on a recognized coordinate system such as latitude/longitude; state plane coordinate systems; UTM coordinate systems; coordinate transformations; scale factors; and meridian convergence.

- Select appropriate vertical and horizontal datum and basis of bearings.
- Perform geodetic surveys using conventional methods.
- Perform geodetic and plane surveys using GPS methods.
- Perform astronomic measurements.
- Perform hydrographic, record or as-built, ALTA/ACSM, photogrammetric control, boundary, route and right-of-way, topographic, and flood plain surveys.
- Perform differential and trigonometric leveling.
- Compute, analyze, and adjust survey data.
- Convert survey data to an appropriate datum.
- Determine levels of precision and order of accuracy.
- Produce survey data using photogrammetric methods.
- Prepare work sheets for analysis of surveys.
- Determine locations of boundary lines and encumbrances.
- Develop and provide data for LIS/GIS.

VI. Computer Operations and Programming (6%)

This area includes operating systems; graphical user interfaces (Windows); data flow; bits and bytes; internet; computer architecture; programming a computer in a compiled language; order of arithmetic operations; programming concepts such as decision statements; flow charts; looping; arrays; and spreadsheet operations.

- Compute, analyze and adjust survey data.
- Convert survey data to an appropriate datum.
- Utilize computer-aided drafting systems.

VII. Written Communication (6%)

This area includes written communication; grammar; sentence structure; punctuation; and bibliographical referencing.

- Evaluate project elements to define scope of work.
- Prepare and negotiate proposals and contracts.

- Consult and coordinate with allied professionals and regulatory agencies.
- Consult with and advise clients and their agents.
- Facilitate regulatory review and approval of project documents and maps.
- Determine and secure entry rights.
- Gather parcel evidence.
- Perform boundary surveys.
- Advise clients regarding boundary uncertainties.
- Review documents with clients and attorneys.
- Prepare sketches and preliminary plats.
- Prepare survey maps, plats, and reports.
- Prepare land descriptions.

VIII. Boundary Law, Cadastral Law, and Administration (13%)

This area includes land descriptions; real property rights; concepts of land ownership; case law; statute law; conveyancing; official records; land record sources; legal instruments of title; U.S. Public Land Survey System; colonial/metes and bounds survey system; subdivision survey system; other cadastral systems; rules of evidence relative to land boundaries and court appearance; boundary control and legal principles; order of importance of conflicting title elements; possession principles; conflict resolution; riparian/littoral water boundaries; boundary evidence; and simultaneous and sequential conveyance.

- Facilitate regulatory review and approval of project documents and maps.
- Determine and secure entry rights.
- Research and evaluate evidence from public and private record sources.
- Research and evaluate court records and case law.
- Gather and evaluate parcel evidence.
- Perform boundary, condominium, route, and right-of-way surveys
- Reconcile survey and record data.
- Identify and evaluate field evidence for possession, boundary line discrepancies, and potential adverse possession claims.
- Identify riparian and littoral boundaries.
- Apply Public Land Survey System and other survey system principles.
- Evaluate the priority of conflicting title elements.
- Determine locations of boundary lines and encumbrances.
- Advise clients regarding boundary uncertainties.

- Testify as an expert witness.
- Review documents with clients and attorneys.
- Determine subdivision development requirements and constraints.
- Determine and prepare lot and street patterns for land division.
- Perpetuate and establish monuments and their records.
- Document potential possession claims.
- Prepare and file record of survey.
- Identify pertinent physical features, landmarks, and existing monumentation.
- Prepare survey maps, plats, and reports.
- Prepare land descriptions.

IX. Business Law, Management, Economics, Finance, Survey Planning Process and Procedures (6%)

This area includes sole proprietorships, corporations, partnership structures; contract law; tax structure; employment law; liability; operation analysis and optimization; land economics; appraisal science; critical path analysis; human resource management principles; cost/benefit analysis of a project or operation; economic modeling; time value of money; budgeting; techniques for planning and conducting surveys including boundary, control, hydrographic, topographic, route, aerial, and construction surveys; and issues related to professional liability, ethics and courtesy.

- Evaluate project elements to define scope of work.
- Prepare and negotiate proposals and contracts.
- Consult and coordinate with allied professionals and regulatory agencies.
- Consult with and advise clients and their agents.
- Facilitate regulatory review and approval of project documents and maps.
- Determine and secure entry rights.
- Advise clients regarding boundary uncertainties.
- Testify as an expert witness.
- Review documents with clients and attorneys.
- Document potential possession claims.
- Prepare survey maps, plats, and reports.
- Develop and provide data for LIS/GIS.

X. Field Data Acquisition and Reduction (10%)

This area includes field notes and electronic data collection; measurement of distances, angles, and directions; modern instruments and their construction and

use; tapes; levels; theodolites; total stations; EDMs; GPS; hydrographic data collection instruments; construction layout instruments and procedures for routes and structures; and historical measurement methods.

- Determine levels of precision and order of accuracy.
- Recover horizontal/vertical control.
- Identify pertinent physical features, landmarks, and existing monumentation.
- Calibrate instruments.
- Perform geodetic and plane surveys using conventional and GPS methods.
- Perform astronomic measurements.
- Perform record or as-built, ALTA/ACSM, hydrographic, photogrammetric control, boundary, route and right-of-way, topographic, flood plain, construction, and condominium surveys.
- Perform differential and trigonometric leveling.
- Perform field verifications of photogrammetric maps.
- Produce survey data using photogrammetric methods.
- Perpetuate and establish monuments and their records.

XI. Photo/Image Data Acquisition and Reduction (4%)

This area includes cameras; image scanners; digitizers; stereo plotters; photo and stereomodel orientation; ortho-photo production; georectification; image processing; and raster/vector data conversions.

- Determine levels of precision and order of accuracy.
- Perform record or as-built, ALTA/ACSM, photogrammetric control, topographic, and flood plain surveys.
- Perform field verifications of photogrammetric maps.
- Produce survey data using photogrammetric methods.
- Utilize survey data produced from photogrammetric methods.
- Prepare survey maps, plats and reports.

XII. Graphical Communication, Mapping (6%)

This area includes principles of effective graphical display of spatial information; preparation of sketches, scale drawings, survey plats, and maps; interpretation of features on three-dimensional drawings; principles of

cartography and map projections; computer mapping; and use of overlays.

- Perform record or as-built and ALTA/ACSM surveys.
- Produce survey data using photogrammetric methods.
- Utilize survey data produced from photogrammetric methods.
- Prepare work sheets for analysis of surveys.
- Utilize computer-aided drafting systems.
- Determine and prepare lot and street patterns for land division.
- Design horizontal and vertical alignment for roads within a subdivision.
- Prepare sketches and preliminary plats.
- Prepare and file record of survey.
- Prepare survey maps, plats, and reports.
- Develop and provide data for LIS/GIS.

XIII. Plane Survey Calculation (10%)

This area includes computation and adjustment of traverses; COGO computation of boundary lines, route alignments, construction layout, and subdivision plats; and calculation of route curves and volumes.

- Determine levels of precision and order of accuracy.
- Calibrate instruments.
- Perform geodetic and plane surveys using conventional and GPS methods.
- Perform astronomic measurements.
- Perform record or as-built, ALTA/ASSM, hydrographic, photogrammetric control, boundary, route and right-of-way, topographic, flood plain, construction, and condominium surveys.
- Perform trigonometric and differential leveling.
- Produce survey data using photogrammetric methods.
- Compute, analyze, and adjust survey data.
- Reconcile survey and record data.
- Convert survey data to an appropriate datum.
- Prepare work sheets for analysis of surveys.
- Determine locations of boundary lines and encumbrances.
- Determine and prepare lot and street patterns for land division.
- Design horizontal and vertical alignment for roads within a subdivision.
- Develop and provide data for LIS/GIS.

XIV. Geographic Information Systems (GIS) Concepts (4%)

This area includes spatial data storage, retrieval, and analysis systems; relational database systems; spatial objects; attribute value measurement; data definitions; schemas; metadata concepts; coding standards; GIS analysis of networks; buffering; overlay; and spatial data accuracy standards.

- Utilize computer-aided drafting systems.
- Perpetuate and establish monuments and their records.
- Prepare and file records of surveys.
- Prepare survey maps, plats, and reports.
- Develop and provide data for LIS/GIS.

XV. Land Development Principles (5%)

This area includes land planning and practices; laws controlling land use; drainage systems; construction methods; geometric and physical aspects of site analysis; design of land subdivisions; street alignment calculations; and application of subdivision standards.

- Prepare sketches and preliminary plats.
- Prepare survey maps, plats, and reports.
- Prepare land descriptions.
- Evaluate project elements to define scope of work.
- Prepare and negotiate proposals and contracts.
- Consult and coordinate with allied professionals and regulatory agencies.
- Consult with and advise clients and their agents.
- Facilitate regulatory review and approval of project documents and maps.
- Determine subdivision development requirements and constraints.
- Determine and prepare lot and street patterns for land division.
- Perpetuate and establish monuments and their records.
- Design horizontal and vertical alignment for roads within a subdivision.

Exam Scoring

The Fundamentals examination is not graded on a curve; a certain minimum competency must be demonstrated to safeguard the public welfare. Nevertheless, it is recognized that the tests may vary slightly in difficulty, depending upon the questions selected for a particular examination. Therefore, questions are reviewed by committees of practicing land surveyors before the

examinations. These committees evaluate the difficulty of each question in order to develop a recommended passing score for each examination. However, the individual state boards have the authority to determine the passing score in their respective states. In the grading process, credit is given for each correct answer and no points are deducted for incorrect answers. The sum of the correct answers is scaled so that the grade of 70 reflects the standard minimum competency.

Use of Calculators and Computers in the Exam

The exam requires use of a scientific calculator. However, 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 the Professional Publications website (www.ppi2pass.com/calculators.html). Nomographs and specialty slide rules are permitted.

Laptop computers are generally not permitted in the examination. You may not use a walkie-talkie, cell phone, or other communications devices during the exam. You may not share calculators with other examinees.

Be sure you take your calculator with you whenever you leave the examination room for any length of time.

Permitted Reference Manual

The FS exam is “closed book.” No reference material of any kind may be used. However, each examination contains a collection of pertinent reference formulas that may be used. These include formulas for triangle solutions, horizontal and vertical curves, statistics, state plane coordinates, earthwork, tape correction, astronomy, photogrammetry, and stadia. In addition, some conversion factors are provided. Typical formulas that will be provided are included in this publication by permission of NCEES. However, it is emphasized that the formulas and conversion factors provided are not necessarily all-inclusive. Formulas and conversion factors other than those provided may be necessary to complete the examination. Therefore, a well-prepared examinee should know many of the basic formulas.

Cheating and Exam Subversion

The proctors for this exam are well trained in enforcing the regulations regarding misuse of reference materials and other types of cheating. Obviously, you should not talk to other examinees in the room during the examination, nor should you pass notes back and forth. Typically, the number of people released to use the rest rooms at any given time during the exam may be restricted, to prevent discussions.

The NCEES regularly reuses good problems that have appeared on previous exams. Therefore, security is a serious issue for the NCEES, which goes to great lengths to prevent problem copying. You may not keep your

exam booklet at the end of the day, enter text of problems into your calculator, or copy problems onto your own materials.

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

PREPARATION FOR THE EXAM

Plan Your Attack

Preparation for the Fundamentals examination should be considered a long-term project. As currently structured, the examination is both comprehensive and fast paced. Rapid recall, discipline, stamina, and mastery of all areas to be covered are essential to succeed on the examination. Development of these skills may require months of preparation, in addition to the years of academic study and work experience necessary to qualify for the examination.

It is suggested that preparation follow these steps:

1. Review this publication to gain insight into the nature and content of the examination, as well as into typical questions that might be included.
2. Thoroughly review each of the major areas to be tested by carefully reading through various publications such as those listed in the following section, and by answering review questions and problems in such texts.

It is a good idea to prepare a concise outline as you work through each area. In many areas, review courses are available that will be helpful during this stage of preparation. This review should be on a rigorous schedule to help you develop the discipline and stamina necessary to do well on the examination.

3. Take the sample examination contained within this publication to evaluate your readiness for the examination.
4. Work on any weak areas detected by your sample examination.
5. Conduct a final review of your notes.

Additional Reference Materials

Numerous texts are available that cover fundamentals of surveying. The following are several of the author's personal favorites, which offer comprehensive coverage of the areas to be tested on the examination. Edition numbers have been omitted since new editions are often issued. Areas for which these references are especially recommended are indicated in parentheses.

Brown, C. M., Robillard, W. G., and Wilson, D. A. *Boundary Control and Legal Principles*. New York, NY: John Wiley & Sons.

(legal principles)

Brown, C. M., Robillard, W. G., and Wilson, D. A. *Evidence and Procedures for Boundary Location*. New York, NY: John Wiley & Sons.

(legal principles, especially those dealing with descriptions)

Buckner, R. B. *A Manual on Astronomic and Grid North*. Rancho Cordova, CA: Landmark Enterprises.

(survey astronomy)

Bureau of Land Management. *Manual of Instruction for Surveys of Public Lands*. Washington, DC: Superintendent of Documents.

(legal principles and techniques for public land surveys and retracements of such surveys)

Cole, G. M. *Water Boundaries*. New York, NY: John Wiley & Sons.

(legal principles and computational techniques for riparian and littoral boundaries)

Colley, Barbara C. *Practical Manual of Land Development*. New York, NY: McGraw-Hill.

(land development)

Davis, R. E., Foote, F. S., Anderson, J. M., and Mikhail, E. M. *Surveying Theory and Practice*. New York, NY: McGraw-Hill.

(computations, measurements, and research)

Denny, Milton E. *Surveyors and Engineers Small Business Handbook*. Tuscaloosa, AL: CED Technical Services.

(management)

Harbin, A. L., and Cole, G. M. *Surveyor Reference Manual*. Belmont, CA: Professional Publications.

(computations, measurements, sample problems)

Hickerson, Thomas F. *Route Location and Design*. New York, NY: McGraw-Hill.

(route survey computations)

Lindeburg, Michael R. *Engineering Economic Analysis*. Belmont, CA: Professional Publications.

(economics and finance)

Robillard, W. G. and Bouman, L. J. *Clark on Surveying and Boundaries*. Charlottesville, VA: The Michie Co.

(legal principles)

Smith, James R. *Introduction to Geodesy*. New York, NY: John Wiley & Sons.

(geodesy)

Van Sickle, Jan. *GPS for Land Surveyors*. Boca Raton, FL: Ann Arbor Press.

(GPS)

Wattles, W. C. *Land Survey Descriptions*. Orange, CA: Gurdon Wattles Publications.
(land descriptions)

Wolf & Dewitt. *Elements of Photogrammetry (with Applications in GIS)*. New York, NY: McGraw-Hill.
(photogrammetry, GIS)

Wolf & Ghilani. *Adjustment Computations*. New York, NY: John Wiley & Sons.
(adjustments)

Last-Minute Preparation

A week or so before the exam, you should conduct an intensive review of the outlines prepared during your review. However, do not attempt to cram during the last night before the exam.

During the last week or so before the exam, make arrangements 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 it is convenient, visit the examination site to locate the building, parking areas, examination rooms, and rest rooms.

You should always take a backup calculator to the exam. If your spare calculator is not the same type as your primary one, spend some time familiarizing yourself with its functioning. Make sure that you have correct-sized replacement batteries for both calculators. In addition, you should prepare a kit of items and reference materials to be taken to the examination.

Schedule a vacation from your job on the day before the exam so you can relax. A day off and a good night's sleep is the best way to start the exam. If you live a considerable distance from the examination site, consider getting a hotel room nearby in which to spend the night. Calculate your wake-up time and set two alarms. Select and lay out your clothing and breakfast items, and make sure you have gas in your car and money in your wallet.

TAKING THE EXAM

What to Take to the Exam

In addition to your review, another important aspect of exam preparation is the selection of materials to be taken to the exam. There are a number of documents, tools, and personal comfort items you should pack in your exam kit. The following is a list of suggestions.

- letter admitting you to the exam
- photo identification (such as driver's license)
- eyeglasses
- primary calculator
- spare calculator

- spare batteries for calculators
- ruler and protractor
- unobtrusive snacks or candies
- travel pack of tissues
- handkerchief
- headache remedy
- several dollars in change
- light jacket or sweater
- wristwatch with alarm

As a final touch, take along the morning newspaper to read while waiting for the exam to begin. You should not take your cell phone to the examination. At the very least, be sure to turn it off before the exam begins.

What to Do During the Exam

Arrive at least 30 minutes before the exam is scheduled to start. This will allow time for finding a convenient parking place, getting your materials into the examination room, finding a good seat, and calming down. Be prepared, though, to find that the exam room is not open or ready at the designated time. Once you have arranged your materials on your table, take out your morning newspaper and look cool.

All of the procedures typically associated with timed, proctored, computer-graded assessment tests will be in effect when you take your licensure examination. The proctors will distribute the examination booklets and answer sheets. However, you should not open the booklets until instructed to do so.

Listen carefully to everything the proctors say. Do not ask the proctors any surveying questions. Even if knowledgeable in surveying, they are not permitted to answer your questions. They will guide you through the process of writing your name and other biographical information on the material. Time allotted for instructions and for initializing the answer sheets is not part of the timed exam period.

The common instructions to completely fill the bubbles and erase completely apply here. The NCEES provides each examinee with a mechanical pencil with an eraser. To ensure that you receive proper credit, fill in all your responses on the answer sheet with a dark pencil mark.

All the questions on the exam are worth the same number of points, so it's a good idea to answer every question you can within a reasonable 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 after you have answered all of the "easy" questions.

Many points are lost due to carelessness. Therefore, it is a good idea to read each question twice before solving. Check to make sure that you've used all of the given data and made the appropriate unit conversions. While the exam questions are not tricky, you may find that answers using commonly made mistakes are represented among the available answer choices. Thus, just because there is an answer choice that matches your result, it does not mean that you have obtained the correct result.

The FS exam is multiple choice with credit given for correct answers. No credit is deducted for wrong answers. Therefore, it is in your best interest to answer each question. It is a good idea to set your wristwatch alarm for five minutes before the end of each session and use that time to guess at all of the 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 five minutes.

If you finish the exam early and there are still more than 30 minutes remaining, you will be permitted to leave the room. If you finish less than 30 minutes before the end of the exam, you may be required to remain until the end in consideration of the people who are still working. You will not be permitted to keep your examination booklet for later review. When you leave, you must return it to the proctors.

After the Exam

People react quite differently to the examination experience. Some are energized and need to unwind by talking with other examinees, describing every detail of their experience, and dissecting every examination question. However, most 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. They 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 coworker might receive his or her notification today, and you might have to wait another three weeks. It all depends on when the entire process is completed. Some states are required 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 from state to state, and so do numerous other factors. Therefore, you'll just have to wait patiently.

You will typically receive your results within 12 weeks of the exam. 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 examinations and about how to prepare for them, the rest is up to you. Plan your attack, and get to work. The very best of luck to you!