RELEASED EXAM

1997

AP® Statistics

CONTAINS:

- **Multiple-Choice Questions and Answer Key**
- **Free-Response Questions, Scoring Guidelines, and Sample Student Responses and Commentary**
- **Statistical Information About Student Performance on the 1997 Exam**

Advanced Placement Program®

The College Board
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The Advanced Placement Examination in Statistics

Contains:

- Multiple-Choice Questions and Answer Key
- Free-Response Questions, Scoring Guidelines, and Sample Student Responses and Commentary
- Statistical Information about Student Performance on the 1997 Exam

Chapter I The AP Process

- Who Develops the AP Statistics Exam?
- How Do They Develop It?
  - Section I
  - Section II
- Question Types
  - Multiple Choice
  - Free Response
- Scoring the Exam
  - Who Scores the AP Statistics Exam?
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  - Training Faculty Consultants to Apply the Scoring Guidelines
  - Maintaining the Scoring Guidelines
- Preparing Students for the Exam
- Teacher Support

This chapter will give you a brief overview of what goes on behind the scenes during the development and grading of the AP Statistics Exam. You can find more detailed information in the "Technical Corner" of the AP website (www.collegeboard.org/ap).

Who Develops the AP Statistics Exam?

The AP Statistics Development Committee, working with content experts at Educational Testing Service (ETS), is responsible for creating the exam. This committee is made up of eight teachers from secondary schools, colleges, and universities in different parts of the United States. The members provide different perspectives: AP high school teachers offer valuable advice regarding realistic expectations when matters of content coverage, skills required, and clarity of phrasing are addressed. On the other hand, college and university faculty members ensure that the questions are at the appropriate level of difficulty for an introductory college course in statistics. Each member typically serves for three years.

Another person who aids in the development process is the Chief Faculty Consultant (CFC). He or she attends every committee meeting to ensure that the free-response questions selected for the exam can be scored reliably. You can find out more about the role of the CFC, and the scoring process in general, on pages 2–4.

How Do They Develop It?

It takes at least two years to develop each AP Statistics Exam. The development process is different for multiple-choice and free-response sections:

Section I

1. Each committee member independently writes a selection of multiple-choice questions based on the course content outline.
2. The committee convenes to review these draft questions, and eliminates any language, symbols, or content that may be offensive to major subgroups of the test-taking population. In addition, statistical procedures help the committee identify possibly unfair items.
3. Most of the multiple-choice questions are pretested in college classes to obtain some estimate of the question's level of difficulty.
4. The questions that make it through these screening processes are assembled according to test specifications developed by the committee and, after further editing and checking, comprise Section I of the AP Statistics Exam.

The committee controls the level of difficulty of the multiple-choice section by including a variety of questions at different levels of difficulty.

Section II

1. Individual committee members write a selection of free-response questions based on the course content outline.
2. The committee reviews and refines draft questions, and determines which will work well for the AP Exam. They consider, for example, whether the questions will offer an appropriate level of difficulty and whether they will elicit answers that allow faculty consultants to discriminate among the responses along a particular scoring scale. An ideal question enables the stronger students to demonstrate their accomplishments while revealing the limitations of less advanced students.

In the last stage of development, committee members give approval to a final draft of all multiple-choice and free-response questions. This review takes place several months before the administration of the exam.

Question Types

The AP Exam in Statistics contains a 90-minute multiple-choice section and a 90-minute free-response section. The two sections are designed to complement each other and to meet the overall course objectives and exam specifications.

Multiple-choice questions are obviously useful for measuring the breadth of content in the curriculum. In addition, they have three other strengths:

1. They are highly reliable. Reliability, or the likelihood that candidates of similar ability levels taking a different form of the exam will receive the same scores, is controlled more effectively with multiple-choice questions than with free-response questions.
2. They allow the Development Committee to include a selection of questions at various levels of difficulty, thereby ensuring that the measurement of differences in students' achievement is optimized. For AP Exams, the most important distinctions are between students earning the grades of 2 and 3, and 3 and 4. These distinctions are usually best accomplished by using many questions of middle difficulty.
3. They allow the CFC to compare the ability level of the current candidates with those from another year. A number of questions from an earlier exam are included in the current one, thereby allowing comparisons to be made between the scores of the earlier group of candidates and the current group. This information, along with other data, is used by the CFC to establish AP grades that reflect the competence demanded by the Advanced Placement Program, and that compare with earlier grades.

Free-response questions on the AP Statistics Exam require students to use their analytical and organizational skills to formulate cogent answers. They also allow students:

1. To relate different content areas as they formulate a complete solution to a statistics or probability problem.
2. To present uncommon yet correct responses.
3. To demonstrate their mastery of statistics by a show of creativity.

Free-response and multiple-choice questions are analyzed both individually and collectively after each administration, and the conclusions are used to improve the following year's exam.

Scoring the Exam

Who Scores the Statistics Exam?

The people who score the free-response section of the AP Statistics Exam are known as "faculty consultants." These faculty consultants are experienced statistics instructors who either teach the AP course in a high school, or the equivalent course at a college or university. Great care is taken to get a broad and balanced group of teachers. Among the factors considered before appointing someone to the role are school locale and setting (urban, rural, etc.), gender, ethnicity, and years of teaching experience. If you are interested in applying to be a faculty consultant at a future AP Reading, you can complete and submit an online application in the "Teachers" section of the AP website (www.collegeboard.org/ap), or request a printed application by calling (609) 406-5384.

During the second week of June 1997, 56 teachers of statistics, about half from colleges and half from high schools, gathered at the College of New Jersey, Trenton. Among these teachers, eight were invited to serve as "table leaders" and to come to the Reading two days early to help lead the effort. The remaining 48 readers were divided into eight teams of six readers each, with each team reporting to one table leader. Under the guidance of the Chief Faculty Consultant, the table leaders had responsibility for organizing the details of the Reading and conveying information to the readers in the respective teams.

Ensuring Accuracy

The primary goal of the scoring process is to have each faculty consultant score his or her set of papers fairly, uniformly, and to the same standard as the other faculty consultants. This is achieved through the creation of detailed scoring guidelines, the thorough training of all faculty consultants, and various "checks and balances" applied throughout the AP Reading.

How the Scoring Guidelines are Created

1. Before the AP Reading, the CFC prepares a draft of the scoring guidelines for each free-response question. In the case of Statistics, a 5-point scale (0-4) was used. A score of 0 means the student received no credit for the problem.
2. The CFC, question leaders, table leaders, and ETS content experts meet at the Reading site a few days before the reading begins. They review and revise the draft scoring guidelines, and test them by pregrading randomly selected student papers. The Statistics leaders were satisfied that this method allowed for consistent scoring of open-ended questions for which many different approaches could be equally correct and for which a written statement on assumptions and conclusions was required. If problems or ambiguities become apparent, the scoring guidelines are revised and refined until a final consensus is reached.
3. The CFC, question leaders, and table leaders conduct training sessions for each free-response question, which are attended by all the faculty consultants who are scoring that question.

Training Faculty Consultants to Apply the Scoring Guidelines

Since the training of the faculty consultants is so vital in ensuring that students receive a grade that accurately reflects their performance, the process is thorough:

1. The faculty consultants read sample papers that have been pregraded (see above). These samples reflect all levels of ability.
2. Each group of faculty consultants then compares and discusses the scores for the samples, based on the scoring guidelines.
3. Once the faculty consultants as a group can apply the standards consistently and without disagreement, they begin reading in teams of two. Each team member scores a packet of five papers and then exchanges the examinations for a second reading. Scores and differences in judgment are discussed until agreement is reached, with the question leaders, the table leaders, or the CFC acting as arbitrator when needed.
4. After a team shows consistent agreement on its scores, its members proceed to score individually. Faculty consultants are encouraged to seek advice from each other, the question leaders and table leaders, or the CFC when in doubt about a score. A student response that is problematic receives multiple readings and evaluations.

Maintaining the Scoring Guidelines

A potential problem is that a faculty consultant could give an answer a higher or lower score than it deserves because the same student has performed well or poorly on other questions. The following steps are taken to prevent this so-called "halo effect:"

- Each question is read by a different faculty consultant;
- All scores given by other faculty consultants are completely masked; and
- The candidate's identification information is covered. Using these practices permits each faculty consultant to evaluate free-response answers without being prejudiced by knowledge about individual candidates.

Here are some other methods that help ensure that everyone is adhering closely to the scoring guidelines:

- The entire group discusses pregraded papers each morning, and as necessary during the day.
- Table leaders re-read (back read) a portion of the student papers from each of the readers in that leader's team. This approach allows each leader to guide his or her readers toward appropriate and consistent interpretations of the rubrics.
- Faculty consultants are paired, so that every reader has a partner to check consistency and to discuss problem cases with; table leaders were also paired up to help each other on questionable calls.
- The CFC and the question leaders monitor use of the full range of the scoring scale for the group and for each faculty consultant by checking daily graphs of score distributions.

Preparing Students for the Exam

The AP Statistics course is designed to be comparable to a typical non-calculus-based introductory statistics course taught in a college or university department of mathematics, mathematical sciences, or statistics. The outline of topics for the course was developed after careful study of the components of modern statistics courses taught in these venues. There are a wide variety of statistics courses taught with emphasis in business, social sciences, engineering, or other concentrations that would not necessarily be equivalent to the AP course, although there should be considerable overlap. Thus, it is important that the student and AP teacher understand the type of college course toward which the AP course is directed.

As outlined in the AP Statistics Course Description, the course emphasizes four main areas:

- Exploring Data: observing patterns and departures from patterns
- Planning a Study: deciding what and how to measure
- Anticipating Patterns: producing models using probability and simulation
- Statistical Inference: confirming models

Compared to most equivalent college courses, the AP syllabus is actually much more ambitious. The more comprehensive outline can be accommodated in the AP course because it usually runs for a full academic year, as opposed to the typical single semester devoted to the course at the college level. The extra topics and depth of coverage to which the AP student is exposed prepares that student for a wide variety of college courses found within the mathematical sciences arena.

The AP Statistics course emphasizes modern data analysis (defining a problem, designing a data collection plan, collecting data, analyzing data, and making decisions through data) rather than the theory of statistics or probability. Technology, then, has a key role to play in the learning of the subject since the computer is the chief tool for modern data analysis. Students should have some experience with statistical software and be able to read standard computer printouts. Because a computer cannot be used on the exam, each student is expected to have access to a graphing calculator with standard statistical functions. Some calculations may be required on the exam.

In the final analysis, students must have completed a serious course in the basics of modern statistical methods and practice, with some exposure to probability as it is used to describe statistical distributions and some experience with modern statistical technology. Even with a full year to master this material, many students will find this is a difficult agenda to complete. The developers of the AP Statistics program, knowing that the course is quite demanding, have tried to alleviate some of the pressure by tying key ideas to current strands in statistics that are developing throughout the K-12 mathematics curriculum. The basics of exploring data can begin in the elementary grades, for example, and simulation as a tool to understand statistical distributions can begin in the middle grades. In that way, statistics becomes a way of using data to solve problems with consistent and repeating themes throughout the student's K-12 experience. Viewed in these terms, the AP syllabus does not seem as imposing as at first sight.

Teacher Support

There are a number of resources available to help teachers prepare their students — and themselves — for the AP course and exam.

AP workshops and summer institutes. New and experienced teachers are invited to attend workshops and seminars to learn the rudiments of teaching an AP course as well as the latest in each course's expectations. Sessions of one day to several weeks in length are held year-round. Dates, locations, topics, and fees are available from the College Board's Regional Offices (see the inside front cover of this booklet), in the publication *Graduate Summer Courses and Institutes*, or in the "Teachers" section of our website (see below).

AP's corner of College Board Online® You can supplement your AP course and preparation for the exam with plentiful advice and resources from our AP web pages (www.collegeboard.org/ap).

Online discussion groups. The AP Program has developed an interactive online mailing list for each AP subject. Many AP teachers find this free resource to be an invaluable tool for sharing ideas with colleagues on syllabi, course texts, teaching techniques, and so on, and for discussing other AP issues and topics as they arise. To find out how to subscribe, go to the "Teachers" section of our website.

AP publications and videos. See the Appendix for descriptions of a variety of useful materials for teachers. Of particular interest is the publication that complements this Released Exam - the Packet of 10. Teachers can use these multiple copies of the 1997 AP Statistics Exam, which come with blank answer sheets, to simulate a national administration in their classroom.

AP videoconferences. Several videoconferences are held each year so that AP teachers can converse electronically with the high school and college teachers who develop AP courses and exams. Schools that participate in the AP Program are notified of the time, date, and subject of the videoconference in advance. Or, you can contact your Regional Office for more information. Videotapes of each conference are available shortly after the event; see the Appendix for ordering information.

Chapter II The 1997 AP Statistics Examination

- Exam Content and Format
- Purpose of the Exam
- Giving a Practice Exam
- Instructions for Administering the Exam
- The Exam

Exam Content and Format

The 1997 AP Statistics Exam contained questions from all four major areas of content (exploring data, planning a study, probability, and statistical inference) in both the 35-question objective (multiple-choice) and 6-question free-response parts. Each part contributed 50% to the composite score.

The six free-response questions covered the areas of data exploration, study design, probability, statistical inference and fitting models to data. The first five were short-answer questions; the sixth was a longer investigative task carrying 25% of the score for the free-response section.

Question 1. The data exploration question involved cumulative proportions, which is not adequately covered in most standard textbooks, but was based on relatively simple data sets and asked for summary statistics and interpretations well within the content outline for this course.

Question 2. The design question asked students to explain how they would set up an experiment, and a complete response required explanation of both blocking and randomization.

Question 3. The probability question required some knowledge of conditional probability but the answers could be found through logical thinking without appeal to formal theorems on probability.

Questions 4 and 5. The two inference questions were built around scenarios that required the comparison of two proportions and the analysis of the mean of paired differences, respectively. These questions were similar to the typical questions found in textbooks and, hence, generated extensive responses from almost all students taking the exam.

Question 6. The investigative task required the student to critique models already fit to a set of data and then to find a model that did not have the weaknesses of those presented. For this question, students possessing skill with a graphing calculator may appear to have had some advantage over others, but this was offset by a grading scheme that gave as much weight to a good explanation as to clever calculation.

The scoring guidelines for the free-response questions, and sample student responses, can be found in Chapter III.

Purpose of the Exam

The purpose of the AP Statistics Exam is to allow students to demonstrate mastery of the concepts and techniques of modern statistics at the level of a non-calculus-based introductory college course. Such a course is required or recommended for most college majors and, in fact, the numbers of students taking introductory statistics is rapidly approaching the number taking calculus. If a student earns a satisfactory AP grade and consequently credit for the equivalent college course, then that student may have the opportunity to take a second statistics course that will provide the special emphases required of his or her major. Even if no second course is in the offing, the student is prepared to confront statistical issues much earlier in the college program than might otherwise be the case. Students who take the AP Statistics course but opt not to take the exam still have the advantage of background knowledge that will serve them well when they do take statistics as part of their college program of studies.

The above discussion begs the question, "what is the purpose of such a college course?" Students of today, the workforce of tomorrow, live in an information age. Most aspects of their lives, from the food available to eat to the medications available for an illness, from decisions about buying a car to decisions about choosing an occupation, from choices of political candidates to choices of movies or TV programs, are regulated by data that they or someone else has collected and analyzed, for good or ill. Therefore, it behooves students to learn something about data collection and analysis so that they can enjoy life as informed citizens and productive workers. Numeracy, being able to "read" and understand data, is now as important as literacy. In addition to the advantages for life enhancement, introductory statistics provides the basis for the deeper study of the subject required in many fields, including medical science, biology, engineering and psychology. AP Statistics is a good option for any student, but particularly for a student who plans further study in a quantitative field.

Giving a Practice Exam

The following pages contain the instructions, as printed in the 1997 Coordinator's Manual, for administering the AP Statistics Exam. Following these instructions is a copy of the 1997 Statistics Exam. If you wish to use this released exam to test your students, you may wish to use the instructions to create an exam situation that closely resembles a national administration. If so, read only the directions in the boxes to the students; all other instructions are for the person administering the test and need not be read aloud. Some instructions, such as those referring to the date, the time, and page numbers, are no longer relevant; please ignore them.

Another publication that you might find useful is the so-called "Packets of 10." They are just that: packets of ten of the 1997 AP Statistics Exam, each with a blank answer sheet. For ordering information, see the Appendix.

Instructions for Administering the Exam

Students are expected to bring graphing calculators to the Statistics Examination. Before starting the exam administration, make sure no student has a laptop or other portable computer, pocket organizer, device with typewriter-style (QWERTY) keyboard (HP-95, TI-92, etc.), electronic writing pad, or pen input device (Newton, etc.). If a candidate has such a calculator, or does not have a calculator with statistical capabilities, you may give the candidate one from your supply. If a candidate does not want to use the calculator you have provided, have him or her write, date, and sign the statement in the Statistics subheading under "Calculators" in the "Administering the Exam" section. Candidates may have one or two calculators on their desks while Sections I and II are being administered. Candidates with Hewlett Packard 48 Series graphing calculators may use cards designed for use with these calculators. Proctors should make sure infrared ports (Hewlett Packard) are not facing each other.

If you are using these instructions for a regularly scheduled exam, disregard all instructions marked with an arrow (▶).

▶ If you are using these instructions for a late administration, read them carefully beforehand, keeping in mind the following: 1) directions marked with an arrow (▶) apply *only* to proctors giving late administrations; 2) underlined instructions should *not* be read to candidates during a late administration; 3) dates and days to be read aloud during a late administration should be adjusted as necessary.

After completing the general instructions beginning on page 31, say:

It is Tuesday afternoon, May 6, and you will be taking the AP Statistics Exam. You may not use reference materials or unapproved calculators during this examination. If you brought any with you, put them under your chair. Print your name, last name first, on the front cover of the unsealed Section I booklet. . . . Read the directions on the back of the booklet. When you have finished, look up. . . . Look over your answer sheet to make sure you have provided the information requested and marked your responses correctly. . . . Your answer sheet will be scored by machine. Improper gridding may alter your grade. Mark your responses on page 2 of your answer sheet (one response per question). Be certain the number of the question you are answering matches the number on the answer sheet. Use *only* no. 2 pencils to mark your answers on Section I. Your answer marks must be dark and fill the oval completely. Stray marks and smudges may be read as answers by the machine so erase carefully and completely.

Section I of your test contains only multiple-choice questions. Questions in Section I are numbered 1 through 35. Mark your responses on page 2 of your answer sheet. You are not to open the sealed Section II booklet until you are told to do so.

Remember, when you come to the end of the multiple-choice questions, there will be answer ovals left on your answer sheet. The time for Section I is 90 minutes. Scratch paper is not allowed but you may use the margins of your Section I booklet. Are there any questions?

Answer all questions regarding procedure. Set your watch at 12:59. When it reads exactly 1:00 say:

Open your Section I booklet and begin.

While the candidates are working, you and your proctors should make sure they are marking their answers on page 2 of the answer sheet in pencil. The color of page 2 of the answer sheet is purple (blue for late administrations).

Calculator memories need not be cleared before or after the exam. Calculators may not be shared. Communication between calculators is prohibited during the exam. Proctors should walk around and make sure Hewlett Packard calculators' infrared ports are not facing each other.

▶ Underlined instructions should not be read aloud during a late administration.

— AT 2:30 PM —

Stop working. Close your exam booklet. Make sure you printed your name, last name first, on the front cover of your Section I booklet. . . . Do *not* insert your answer sheet in the booklet. I will now collect the answer sheets.

After you have collected an answer sheet from every candidate, say:

Seal the Section I booklet with the three seals provided. Pull off each seal from the backing sheet and press it on the front cover so it just covers the area marked "PLACE SEAL HERE." Fold it over the open edge and press it to the back cover. Use one seal for each open edge. Be careful not to let the seals touch anything except the marked areas. . . .

Collect the sealed Section I exam booklets. Be sure you receive one from every candidate; then give your break instructions. A five-minute break is permitted. Students may talk, move about, or leave the room together to get a drink of water or go to the rest room. **Calculators must remain turned off and must NOT be taken from the examination room.** (See "Breaks During the Examination").

▶ Late Testing Only

GIVE YOUR BREAK INSTRUCTIONS.

After the break, say:

> **Open the package containing your Section II booklet. Turn to the back cover of the booklet, and read the instructions at the upper left. . . . Print your identification information, in pencil, in the boxes. . . . Taking care not to tear the sheet beneath the cover, detach the perforation at the top. . . . Fold the flap down, and moisten and press the glue strip firmly along the entire lower edge. . . . Your identification information should now be covered and will not be known by those scoring your answers.**
>
> **Read the instructions at the upper right of the back cover. Print your initials in the three boxes provided. . . . Next, take two AP number labels from your Candidate Pack and place them in the two bracketed areas, one below the instructions and one to the left. If you don't have number labels left, copy your number from the back cover of your Candidate Pack within both of the bracketed areas. . . . Item 6 provides you with the option of giving Educational Testing Service permission to use your free-response materials for educational research and instructional purposes. Your name would not be used in any way with the free-response materials. Read the statement and answer either "yes" or "no." . . . Are there any questions?**

Answer all questions regarding procedure. Then say:

> **If you will be taking another AP Examination, I will collect your Candidate Pack. You may keep your Candidate Pack if this is your last or only AP examination.**

Collect the Candidate Packs. Then say:

▶ If you are administering the alternate form of the examination for a late administration, DO NOT read the underlined portions in the following two boxes.

> **Read the directions for Section II on the back of your booklet. Look up when you have finished. . . . <u>You may use the insert for scratchwork, but be sure to show your work and write your answers in the Section II booklet. No credit will be given for work shown in the insert.</u> If you need more paper, raise your hand. Are there any questions?**

Answer all questions regarding procedure. Set your watch at 2:29. When it reads exactly 2:30, say:

> **Open the Section II booklet. <u>Tear out the insert in the center of the booklet. . . . Print your name on the upper left-hand corner. I will be collecting the insert at the end of the administration. It will be returned to you tomorrow by your teacher. . . .</u> Begin work on Section II.**

You and your proctors should check to be sure all candidates are writing their answers in the Section II booklets.

—AT 4:00 —

> **Stop working. Close your Section II booklet and keep it closed on your desk. I will now collect your booklets. Remain in your seats, without talking, while the exam materials are being collected.**

Collect the Section II booklets and the green inserts. The alternate exam for late administrations does not have an insert. Be sure you have one of each from every candidate. Check the back of each booklet to make sure the candidate's AP number appears in the two boxes. When all examination materials have been collected, dismiss the candidates. The green inserts may be given to the appropriate teacher for return to the students the first school day after the administration.

Fill in the necessary information for the Statistics Examinations on the appropriate S&R Form.

Alternate exams should be recorded on their respective line on the S&R Form. (Only alternate exams have an item number listed in the column labeled "Item Number.")

Put the exam materials in locked storage until they are returned to ETS in one shipment after your school's last administration. See "Activities After the Exam."

▶ Late Testing Only

STATISTICS

A CALCULATOR MAY BE USED IN BOTH SECTIONS OF THE EXAMINATION. CALCULATORS MAY NOT BE SHARED. REFERENCE MATERIALS MAY NOT BE USED.

Three hours are allotted for this examination: 1 hour and 30 minutes for Section I, which consists of multiple-choice questions, and 1 hour and 30 minutes for Section II, which consists of longer problems. In determining your grade, the two sections are given equal weight. Section I is printed in this examination booklet; Section II, in a separate booklet.

SECTION I

Time — 1 hour and 30 minutes

Number of questions—35

Percent of total grade — 50

Section I of this examination contains 35 multiple-choice questions. Please be careful to fill in only the ovals that are preceded by numbers 1 through 35 on your answer sheet.

General Instructions

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE INSTRUCTED TO DO SO.

INDICATE ALL YOUR ANSWERS TO QUESTIONS IN SECTION I ON THE SEPARATE ANSWER SHEET ENCLOSED. No credit will be given for anything written in this examination booklet, but you may use the booklet for notes or scratchwork. After you have decided which of the suggested answers is best, COMPLETELY fill in the corresponding oval on the answer sheet. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely.

Example:

What is the arithmetic mean of the numbers 1, 3, and 6 ?

(A) 1 (B) $\frac{7}{3}$ (C) 3

(D) $\frac{10}{3}$ (E) $\frac{7}{2}$

Sample Answer

Ⓐ Ⓑ Ⓒ ● Ⓔ

Many candidates wonder whether or not to guess the answers to questions about which they are not certain. In this section of the examination, as a correction for haphazard guessing, one-fourth of the number of questions you answer incorrectly will be subtracted from the number of questions you answer correctly. It is improbable, therefore, that mere guessing will improve your score significantly; it may even lower your score, and it does take time. If, however, you are not sure of the best answer but have some knowledge of the question and are able to eliminate one or more of the answer choices as wrong, your chance of answering correctly is improved, and it may be to your advantage to answer such a question.

Use your time effectively, working as rapidly as you can without losing accuracy. Do not spend too much time on questions that are too difficult. Go on to other questions and come back to the difficult ones later if you have time. It is not expected that everyone will be able to answer all the multiple-choice questions.

Formulas begin on page 12.
Questions begin on page 15.
Tables begin on page 34.

Formulas

(I) Descriptive Statistics

$$\bar{x} = \frac{\sum x_i}{n}$$

$$s_x = \sqrt{\frac{1}{n-1}\sum(x_i - \bar{x})^2}$$

$$s_p = \sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{(n_1-1)+(n_2-1)}}$$

$$\hat{y} = b_0 + b_1 x$$

$$b_1 = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2}$$

$$b_0 = \bar{y} - b_1\bar{x}$$

$$r = \frac{1}{n-1}\sum\left(\frac{x_i - \bar{x}}{s_x}\right)\left(\frac{y_i - \bar{y}}{s_y}\right)$$

$$b_1 = r\frac{s_y}{s_x}$$

$$s_{b_1} = \frac{\sqrt{\frac{\sum(y_i - \hat{y}_i)^2}{n-2}}}{\sqrt{\sum(x_i - \bar{x})^2}}$$

(II) Probability

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

$$E(X) = \mu_x = \sum x_i p_i$$

$$\mathrm{Var}(X) = \sigma_x^2 = \sum (x_i - \mu_x)^2 p_i$$

If X has a binomial distribution with parameters n and p, then:

$$P(X = k) = \binom{n}{k} p^k (1-p)^{n-k}$$

$$\mu_x = np$$

$$\sigma_x = \sqrt{np(1-p)}$$

$$\mu_{\hat{p}} = p$$

$$\sigma_{\hat{p}} = \sqrt{\frac{p(1-p)}{n}}$$

If X has a normal distribution with mean μ and standard deviation σ, then:

$$\mu_{\bar{x}} = \mu$$

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

(III) Inferential Statistics

Standardized test statistic: $\dfrac{\text{estimate} - \text{parameter}}{\text{standard deviation of estimate}}$

Confidence interval: estimate $\pm$ (critical value) $\bullet$ (standard deviation of estimate)

Single-Sample

Statistic	Standard Deviation
Mean	$\dfrac{\sigma}{\sqrt{n}}$
Proportion	$\sqrt{\dfrac{p(1-p)}{n}}$

Two-Sample

Statistic	Standard Deviation
Difference of means (unequal variances)	$\sqrt{\dfrac{\sigma_1^2}{n_1} + \dfrac{\sigma_2^2}{n_2}}$
Difference of means (equal variances)	$\sigma\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}$
Difference of proportions (unequal variances)	$\sqrt{\dfrac{p_1(1-p_1)}{n_1} + \dfrac{p_2(1-p_2)}{n_2}}$
Difference of proportions (equal variances)	$\sqrt{p(1-p)}\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}$

$$\text{Chi-square test statistic} = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

STATISTICS

SECTION I

Time—1 hour and 30 minutes

Number of questions—35

Percent of total grade—50

Directions: Solve each of the following problems, using the available space for scratchwork. Decide which is the best of the choices given and fill in the corresponding oval on the answer sheet. No credit will be given for anything written in the test book. Do not spend too much time on any one problem.

1. *USA Today* reported that speed skater Bonnie Blair had "won the USA's heart," according to a *USA Today*/CNN/Gallup poll conducted on the final Thursday of the 1994 Winter Olympics. When asked who was the hero of the Olympics, 65 percent of the respondents chose Blair, who won five gold medals. The poll of 615 adults, done by telephone, had a margin of error of 4 percent. Which of the following statements best describes what is meant by the 4 percent margin of error?

   (A) About 4 percent of adults were expected to change their minds between the time of the poll and its publication in *USA Today*.
   (B) About 4 percent of adults did not have telephones.
   (C) About 4 percent of the 615 adults polled refused to answer.
   (D) Not all of the 615 adults knew anything about the Olympics.
   (E) The difference between the sample percentage and the population percentage is likely to be less than 4 percent.

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2. An automobile manufacturer claims that the average gas mileage of a new model is 35 miles per gallon (mpg). A consumer group is skeptical of this claim and thinks the manufacturer may be overstating the average gas mileage. If μ represents the true average gas mileage for this new model, which of the following gives the null and alternative hypotheses that the consumer group should test?

(A) H_0: $\mu < 35$ mpg
H_a: $\mu \geq 35$ mpg

(B) H_0: $\mu \leq 35$ mpg
H_a: $\mu > 35$ mpg

(C) H_0: $\mu = 35$ mpg
H_a: $\mu > 35$ mpg

(D) H_0: $\mu = 35$ mpg
H_a: $\mu < 35$ mpg

(E) H_0: $\mu = 35$ mpg
H_a: $\mu \neq 35$ mpg

---

3. A magazine has 1,620,000 subscribers, of whom 640,000 are women and 980,000 are men. Thirty percent of the women read the advertisements in the magazine and 50 percent of the men read the advertisements in the magazine. A random sample of 100 subscribers is selected. What is the expected number of subscribers in the sample who read the advertisements?

(A) 30
(B) 40
(C) 42
(D) 50
(E) 80

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4. A manufacturer makes lightbulbs and claims that their reliability is 98 percent. Reliability is defined to be the proportion of nondefective items that are produced over the long term. If the company's claim is correct, what is the expected number of nondefective lightbulbs in a random sample of 1,000 bulbs?

(A) 20
(B) 200
(C) 960
(D) 980
(E) 1,000

5. When a virus is placed on a tobacco leaf, small lesions appear on the leaf. To compare the mean number of lesions produced by two different strains of virus, one strain is applied to half of each of 8 tobacco leaves, and the other strain is applied to the other half of each leaf. The strain that goes on the right half of the leaf is decided by a coin flip. The lesions that appear on each half are then counted. The data are given below.

Leaf	Strain 1	Strain 2
1	31	18
2	20	17
3	18	14
4	17	11
5	9	10
6	8	7
7	10	5
8	7	6

What is the number of degrees of freedom associated with the appropriate t-test for testing to see if there is a difference between the mean number of lesions per leaf produced by the two strains?

(A) 7
(B) 8
(C) 11
(D) 14
(E) 16

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6. Which of the following is a criterion for choosing a t-test rather than a z-test when making an inference about the mean of a population?

(A) The standard deviation of the population is unknown.
(B) The mean of the population is unknown.
(C) The sample may not have been a simple random sample.
(D) The population is not normally distributed.
(E) The sample size is less than 100.

---

7. A certain county has 1,000 farms. Corn is grown on 100 of these farms but on none of the others. In order to estimate the total farm acreage of corn for the county, two plans are proposed.

Plan I: (a) Sample 20 farms at random.
(b) Estimate the mean acreage of corn per farm in a confidence interval.
(c) Multiply both ends of the interval by 1,000 to get an interval estimate of the total.

Plan II: (a) Identify the 100 corn-growing farms.
(b) Sample 20 corn-growing farms at random.
(c) Estimate the mean acreage of corn for corn-growing farms in a confidence interval.
(d) Multiply both ends of the interval by 100 to get an interval estimate of the total.

On the basis of the information given, which of the following is the better method for estimating the total farm acreage of corn for the county?

(A) Choose plan I over plan II.
(B) Choose plan II over plan I.
(C) Choose either plan, since both are good and will produce equivalent results.
(D) Choose neither plan, since neither estimates the total farm acreage of corn.
(E) The plans cannot be evaluated from the information given.

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8. Which of the following can be used to show a cause-and-effect relationship between two variables?

   (A) A census
   (B) A controlled experiment
   (C) An observational study
   (D) A sample survey
   (E) A cross-sectional survey

---

9. To check the effect of cold temperature on the elasticity of two brands of rubber bands, one box of Brand A and one box of Brand B rubber bands are tested. Ten bands from the Brand A box are placed in a freezer for two hours and ten bands from the Brand B box are kept at room temperature. The amount of stretch before breakage is measured on each rubber band, and the mean for the cold bands is compared to the mean for the others. Is this a good experimental design?

   (A) No, because the means are not proper statistics for comparison.
   (B) No, because more than two brands should be used.
   (C) No, because more temperatures should be used.
   (D) No, because temperature is confounded with brand.
   (E) Yes

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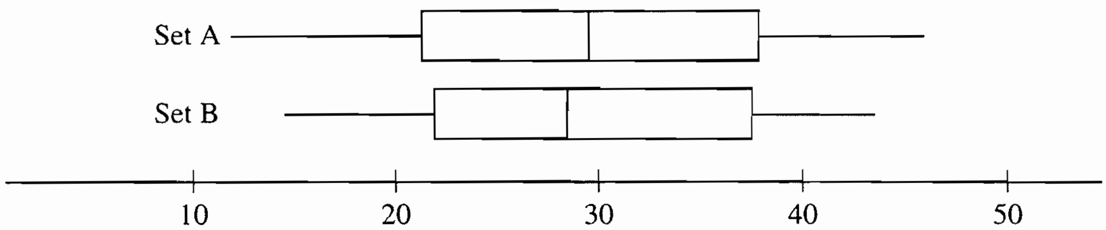

10. The boxplots above summarize two data sets, A and B. Which of the following must be true?

I. Set A contains more data than Set B.
II. The box of Set A contains more data than the box of Set B.
III. The data in Set A have a larger range than the data in Set B.

(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

---

11. The XYZ Office Supplies Company sells calculators in bulk at wholesale prices, as well as individually at retail prices. Next year's sales depend on market conditions, but executives use probability to find estimates of sales for the coming year. The following tables are estimates for next year's sales.

WHOLESALE SALES

Number Sold	2,000	5,000	10,000	20,000
Probability	0.1	0.3	0.4	0.2

RETAIL SALES

Number Sold	600	1,000	1,500
Probability	0.4	0.5	0.1

What profit does XYZ Office Supplies Company expect to make for the next year if the profit from each calculator sold is $20 at wholesale and $30 at retail?

(A) $10,590
(B) $220,700
(C) $264,750
(D) $833,100
(E) $1,002,500

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12. The heights of adult women are approximately normally distributed about a mean of 65 inches with a standard deviation of 2 inches. If Rachael is at the 99th percentile in height for adult women, then her height, in inches, is closest to

(A) 60

(B) 62

(C) 68

(D) 70

(E) 74

13. Joe and Matthew plan to visit a bookstore. Based on their previous visits to this bookstore, the probability distributions of the number of books they will buy are given below.

Number of books Joe will buy	0	1	2
Probability	0.50	0.25	0.25

Number of books Matthew will buy	0	1	2
Probability	0.25	0.50	0.25

Assuming that Joe and Matthew make their decisions independently, what is the probability that they will purchase no books on this visit to the bookstore?

(A) 0.0625
(B) 0.1250
(C) 0.1875
(D) 0.2500
(E) 0.7500

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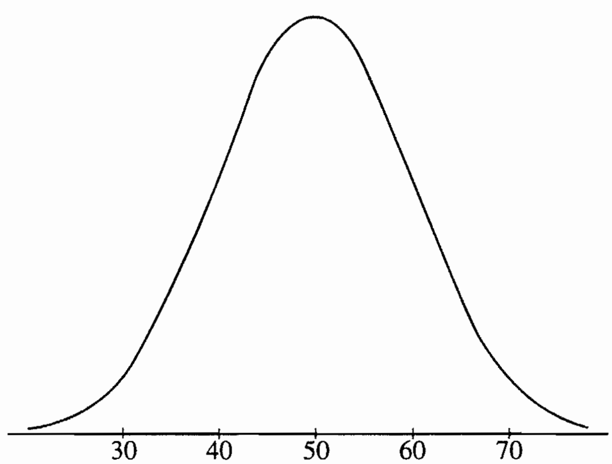
	Job	No Job	Total
Juniors	13	5	18
Seniors	13	26	39
Total	26	31	57

14. A survey of 57 students was conducted to determine whether or not they held jobs outside of school. The two-way table above shows the numbers of students by employment status (job, no job) and class (juniors, seniors). Which of the following best describes the relationship between employment status and class?

(A) There appears to be no association, since the same number of juniors and seniors have jobs.
(B) There appears to be no association, since close to half of the students have jobs.
(C) There appears to be an association, since there are more seniors than juniors in the survey.
(D) There appears to be an association, since the proportion of juniors having jobs is much larger than the proportion of seniors having jobs.
(E) A measure of association cannot be determined from these data.



15. Which of the following is the best estimate of the standard deviation of the distribution shown in the figure above?

(A) 5
(B) 10
(C) 30
(D) 50
(E) 60

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16. Ten students were randomly selected from a high school to take part in a program designed to raise their reading comprehension. Each student took a test before and after completing the program. The mean of the differences between the score after the program and the score before the program is 16. It was decided that all students in the school would take part in this program during the next school year. Let μ_A denote the mean score after the program and μ_B denote the mean score before the program for all students in the school. The 95 percent confidence interval estimate of the true mean difference for all students is (9, 23). Which of the following statements is a correct interpretation of this confidence interval?

(A) $\mu_A > \mu_B$ with probability 0.95.
(B) $\mu_A < \mu_B$ with probability 0.95.
(C) μ_A is around 23 and μ_B is around 9.
(D) For any μ_A and μ_B with $(\mu_A - \mu_B) \geq 14$, the sample result is quite likely.
(E) For any μ_A and μ_B with $9 < (\mu_A - \mu_B) < 23$, the sample result is quite likely.

---

17. Gina's doctor told her that the standardized score (z-score) for her systolic blood pressure, as compared to the blood pressure of other women her age, is 1.50. Which of the following is the best interpretation of this standardized score?

(A) Gina's systolic blood pressure is 150.
(B) Gina's systolic blood pressure is 1.50 standard deviations above the average systolic blood pressure of women her age.
(C) Gina's systolic blood pressure is 1.50 above the average systolic blood pressure of women her age.
(D) Gina's systolic blood pressure is 1.50 times the average systolic blood pressure for women her age.
(E) Only 1.5% of women Gina's age have a higher systolic blood pressure than she does.

18. The Physicians' Health Study, a large medical experiment involving 22,000 male physicians, attempted to determine whether aspirin could help prevent heart attacks. In this study, one group of about 11,000 physicians took an aspirin every other day, while a control group took a placebo. After several years, it was determined that the physicians in the group that took aspirin had significantly fewer heart attacks than the physicians in the control group. Which of the following statements explains why it would not be appropriate to say that everyone should take an aspirin every other day?

I. The study included only physicians, and different results may occur in individuals in other occupations.
II. The study included only males and there may be different results for females.
III. Although taking aspirin may be helpful in preventing heart attacks, it may be harmful to some other aspects of health.

(A) I only
(B) II only
(C) III only
(D) II and III only
(E) I, II, and III

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Questions 19-20 refer to the following information.

Every Thursday, Matt and Dave's Video Venture has "roll-the-dice" day. A customer may choose to roll two fair dice and rent a second movie for an amount (in cents) equal to the numbers uppermost on the dice, with the larger number first. For example, if the customer rolls a two and a four, a second movie may be rented for \$0.42. If a two and a two are rolled, a second movie may be rented for \$0.22. Let X represent the amount paid for a second movie on roll-the-dice day. The expected value of X is \$0.47 and the standard deviation of X is \$0.15.

19. If a customer rolls the dice and rents a second movie every Thursday for 20 consecutive weeks, what is the total amount that the customer would expect to pay for these second movies?

(A) \$0.45
(B) \$0.47
(C) \$0.67
(D) \$3.00
(E) \$9.40

20. If a customer rolls the dice and rents a second movie every Thursday for 30 consecutive weeks, what is the approximate probability that the total amount paid for these second movies will exceed \$15.00 ?

(A) 0
(B) 0.09
(C) 0.14
(D) 0.86
(E) 0.91

21. A company wanted to determine the health care costs of its employees. A sample of 25 employees were interviewed and their medical expenses for the previous year were determined. Later the company discovered that the highest medical expense in the sample was mistakenly recorded as 10 times the actual amount. However, after correcting the error, the corrected amount was still greater than or equal to any other medical expense in the sample. Which of the following sample statistics must have remained the same after the correction was made?

(A) Mean
(B) Median
(C) Mode
(D) Range
(E) Variance

---

22. The back-to-back stem-and-leaf plot below gives the percentage of students who dropped out of school at each of the 49 high schools in a large metropolitan school district.

School Year 1989-1990		School Year 1992-1993
	0	4
9 9 9 9 8 8 7	0	5 6 6 6 7 7 7 8 8 8 9 9
4 4 4 4 4 3 3 2 2 2 2 1 1 1 1 0	1	0 0 0 0 1 1 1 1 2 2 2 3 3 4 4 4 4
9 9 9 7 7 6 6 6 6 5	1	5 5 5 6 6 6 6 7 7 7 7 8
4 2 2 2 1 0 0	2	1 3
8 8 8 7 6	2	
2	3	0 1 1 2
7 6 6	3	5
	4	

For 1992-1993, 1 | 2 represents 12%.

Which of the following statements is NOT justified by these data?

(A) The drop-out rate decreased in each of the 49 high schools between the 1989-1990 and 1992-1993 school years.
(B) For the school years shown, most students in the 49 high schools did not drop out of high school.
(C) In general, drop-out rates decreased between the 1989-1990 and 1992-1993 school years.
(D) The median drop-out rate of the 49 high schools decreased between the 1989-1990 and 1992-1993 school years.
(E) The spread between the schools with the lowest drop-out rates and those with the highest drop-out rates did not change much between the 1989-1990 and 1992-1993 school years.

23. Circuit boards are assembled by selecting 4 computer chips at random from a large batch of chips. In this batch of chips, 90 percent of the chips are acceptable. Let X denote the number of acceptable chips out of a sample of 4 chips from this batch. What is the least probable value of X ?

(A) 0
(B) 1
(C) 2
(D) 3
(E) 4

---

24. A random sample of the costs of repair jobs at a large muffler repair shop produces a mean of \$127.95 and a standard deviation of \$24.03. If the size of this sample is 40, which of the following is an approximate 90 percent confidence interval for the average cost of a repair at this repair shop?

(A) \$127.95 ± \$4.87
(B) \$127.95 ± \$6.25
(C) \$127.95 ± \$7.45
(D) \$127.95 ± \$30.81
(E) \$127.95 ± \$39.53

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25. At a college the scores on the chemistry final exam are approximately normally distributed, with a mean of 75 and a standard deviation of 12. The scores on the calculus final are also approximately normally distributed, with a mean of 80 and a standard deviation of 8. A student scored 81 on the chemistry final and 84 on the calculus final. Relative to the students in each respective class, in which subject did this student do better?

(A) The student did better in chemistry.
(B) The student did better in calculus.
(C) The student did equally well in each course.
(D) There is no basis for comparison, since the subjects are different from each other and are in different departments.
(E) There is not enough information for comparison, because the number of students in each class is not known.

---

26. A fair coin is flipped 10 times and the number of heads is counted. This procedure of 10 coin flips is repeated 100 times and the results are placed in a frequency table. Which of the frequency tables below is most likely to contain the results from these 100 trials?

(A)

Number of Heads	Frequency
0	19
1	12
2	9
3	6
4	2
5	1
6	3
7	5
8	8
9	14
10	21

(B)

Number of Heads	Frequency
0	9
1	9
2	9
3	9
4	9
5	10
6	9
7	9
8	9
9	9
10	9

(C)

Number of Heads	Frequency
0	0
1	0
2	6
3	9
4	22
5	24
6	18
7	12
8	7
9	2
10	0

(D)

Number of Heads	Frequency
0	7
1	10
2	6
3	11
4	8
5	10
6	9
7	12
8	7
9	11
10	9

(E)

Number of Heads	Frequency
0	0
1	0
2	0
3	2
4	24
5	51
6	22
7	1
8	0
9	0
10	0

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27. The student government at a high school wants to conduct a survey of student opinion. It wants to begin with a simple random sample of 60 students. Which of the following survey methods will produce a simple random sample?

(A) Survey the first 60 students to arrive at school in the morning.
(B) Survey every 10th student entering the school library until 60 students are surveyed.
(C) Use random numbers to choose 15 each of first-year, second-year, third-year, and fourth-year students.
(D) Number the cafeteria seats. Use a table of random numbers to choose seats and interview the students until 60 have been interviewed.
(E) Number the students in the official school roster. Use a table of random numbers to choose 60 students from this roster for the survey.

---

28. There is a linear relationship between the number of chirps made by the striped ground cricket and the air temperature. A least squares fit of some data collected by a biologist gives the model

$$\hat{y} = 25.2 + 3.3x \qquad 9 < x < 25,$$

where x is the number of chirps per minute and $\hat{y}$ is the estimated temperature in degrees Fahrenheit. What is the estimated increase in temperature that corresponds to an increase of 5 chirps per minute?

(A) 3.3° F
(B) 16.5° F
(C) 25.2° F
(D) 28.5° F
(E) 41.7° F

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29. In a test of the null hypothesis H_0: $\mu = 10$ against the alternative hypothesis H_a: $\mu > 10$, a sample from a normal population produces a mean of 13.4. The z-score for the sample is 2.12 and the p-value is 0.017. Based on these statistics, which of the following conclusions could be drawn?

(A) There is reason to conclude that $\mu > 10$.
(B) Due to random fluctuation, 48.3 percent of the time a sample produces a mean larger than 10.
(C) 1.7 percent of the time, rejecting the alternative hypothesis is in error.
(D) 1.7 percent of the time, the mean is above 10.
(E) 98.3 percent of the time, the mean is below 10.

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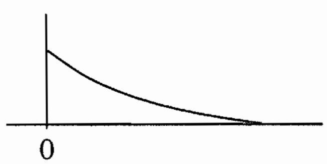
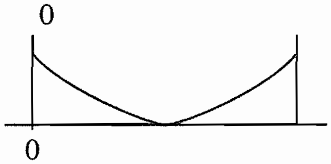
30. For which of the following distributions is the mean greater than the median?

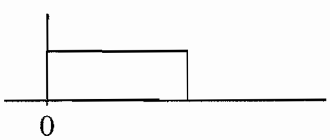
(A)



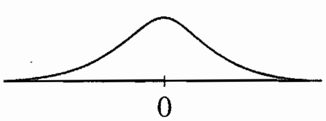
(B)



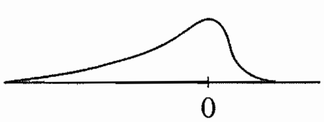
(C)



(D)



(E)



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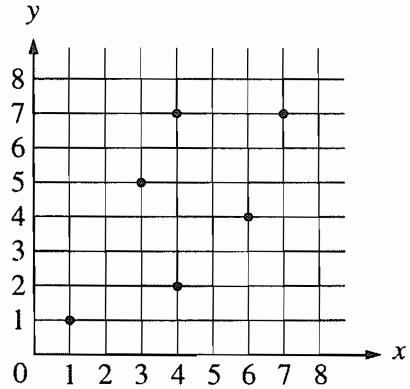

31. The equation of the least squares regression line for the points on the scatterplot above is $\hat{y} = 1.3 + 0.73x$. What is the residual for the point (4, 7) ?

(A) 2.78
(B) 3.00
(C) 4.00
(D) 4.22
(E) 7.00

---

32. The distribution of the weights of loaves of bread from a certain bakery follows approximately a normal distribution. Based on a very large sample, it was found that 10 percent of the loaves weighed less than 15.34 ounces, and 20 percent of the loaves weighed more than 16.31 ounces. What are the mean and standard deviation of the distribution of the weights of the loaves of bread?

(A) $\mu = 15.82$, $\sigma = 0.48$
(B) $\mu = 15.82$, $\sigma = 0.69$
(C) $\mu = 15.87$, $\sigma = 0.50$
(D) $\mu = 15.93$, $\sigma = 0.46$
(E) $\mu = 16.00$, $\sigma = 0.50$

33. A 95 percent confidence interval of the form $\hat{p} \pm E$ will be used to obtain an estimate for an unknown population proportion p. If $\hat{p}$ is the sample proportion and E is the margin of error, which of the following is the smallest sample size that will guarantee a margin of error of at most 0.08 ?

(A) 25
(B) 100
(C) 175
(D) 250
(E) 625

---

34. The process of producing pain-reliever tablets yields tablets with varying amounts of the active ingredient. It is claimed that the average amount of active ingredient per tablet is at least 200 milligrams. The Consumer Watchdog Bureau tests a random sample of 70 tablets. The mean content of the active ingredient for this sample is 194.3 milligrams, while the standard deviation is 21 milligrams. What is the approximate p-value for the appropriate test?

(A) 0.012
(B) 0.024
(C) 0.050
(D) 0.100
(E) 0.488

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35. A survey was conducted to determine what percentage of college seniors would have chosen to attend a different college if they had known then what they know now. In a random sample of 100 seniors, 34 percent indicated that they would have attended a different college. A 90 percent confidence interval for the percentage of all seniors who would have attended a different college is

(A) 24.7% to 43.3%
(B) 25.8% to 42.2%
(C) 26.2% to 41.8%
(D) 30.6% to 37.4%
(E) 31.2% to 36.8%

END OF SECTION I

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY
CHECK YOUR WORK ON SECTION I.
DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.

Table entry for z is the probability lying below z.

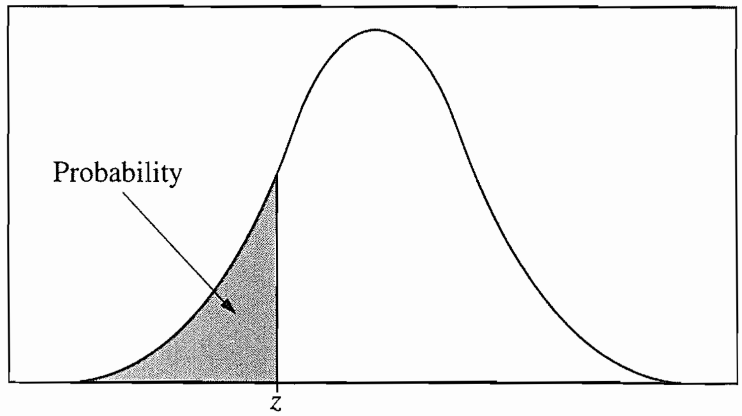


Table A Standard normal probabilities

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
−3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
−3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
−3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
−3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
−2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
−1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
−0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
−0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
−0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
−0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
−0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
−0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
−0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
−0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
−0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
−0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

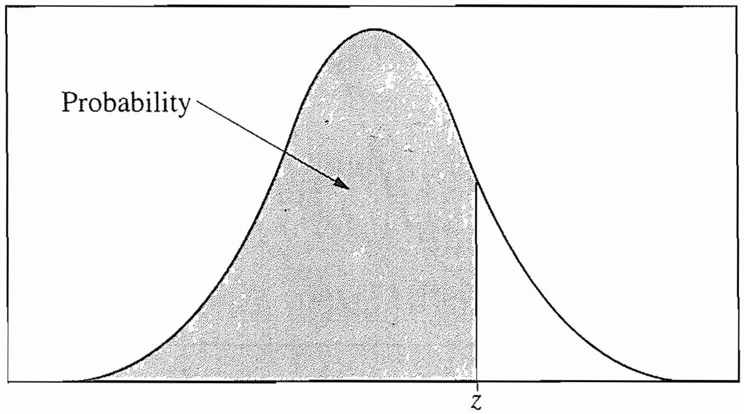


Table entry for z is the probability lying below z.

Table A ***(Continued)***

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

Table entry for p and C is the point t^* with probability p lying above it and probability C lying between $-t^*$ and t^*.

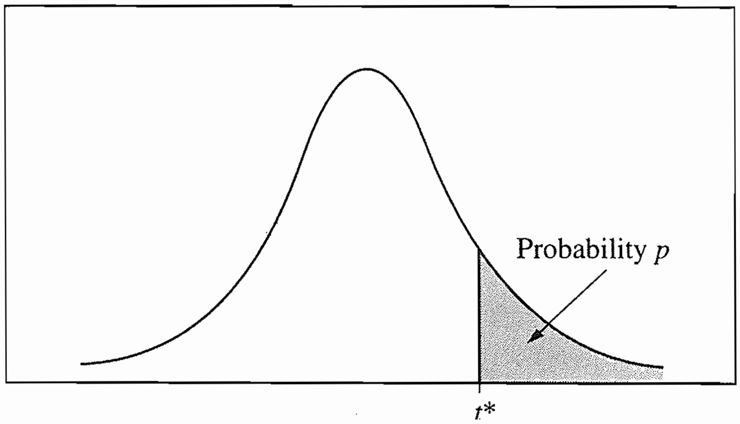


Table B ***t* distribution critical values**

	Tail probability p											
df	.25	.20	.15	.10	.05	.025	.02	.01	.005	.0025	.001	.0005
1	1.000	1.376	1.963	3.078	6.314	12.71	15.89	31.82	63.66	127.3	318.3	636.6
2	.816	1.061	1.386	1.886	2.920	4.303	4.849	6.965	9.925	14.09	22.33	31.60
3	.765	.978	1.250	1.638	2.353	3.182	3.482	4.541	5.841	7.453	10.21	12.92
4	.741	.941	1.190	1.533	2.132	2.776	2.999	3.747	4.604	5.598	7.173	8.610
5	.727	.920	1.156	1.476	2.015	2.571	2.757	3.365	4.032	4.773	5.893	6.869
6	.718	.906	1.134	1.440	1.943	2.447	2.612	3.143	3.707	4.317	5.208	5.959
7	.711	.896	1.119	1.415	1.895	2.365	2.517	2.998	3.499	4.029	4.785	5.408
8	.706	.889	1.108	1.397	1.860	2.306	2.449	2.896	3.355	3.833	4.501	5.041
9	.703	.883	1.100	1.383	1.833	2.262	2.398	2.821	3.250	3.690	4.297	4.781
10	.700	.879	1.093	1.372	1.812	2.228	2.359	2.764	3.169	3.581	4.144	4.587
11	.697	.876	1.088	1.363	1.796	2.201	2.328	2.718	3.106	3.497	4.025	4.437
12	.695	.873	1.083	1.356	1.782	2.179	2.303	2.681	3.055	3.428	3.930	4.318
13	.694	.870	1.079	1.350	1.771	2.160	2.282	2.650	3.012	3.372	3.852	4.221
14	.692	.868	1.076	1.345	1.761	2.145	2.264	2.624	2.977	3.326	3.787	4.140
15	.691	.866	1.074	1.341	1.753	2.131	2.249	2.602	2.947	3.286	3.733	4.073
16	.690	.865	1.071	1.337	1.746	2.120	2.235	2.583	2.921	3.252	3.686	4.015
17	.689	.863	1.069	1.333	1.740	2.110	2.224	2.567	2.898	3.222	3.646	3.965
18	.688	.862	1.067	1.330	1.734	2.101	2.214	2.552	2.878	3.197	3.611	3.922
19	.688	.861	1.066	1.328	1.729	2.093	2.205	2.539	2.861	3.174	3.579	3.883
20	.687	.860	1.064	1.325	1.725	2.086	2.197	2.528	2.845	3.153	3.552	3.850
21	.686	.859	1.063	1.323	1.721	2.080	2.189	2.518	2.831	3.135	3.527	3.819
22	.686	.858	1.061	1.321	1.717	2.074	2.183	2.508	2.819	3.119	3.505	3.792
23	.685	.858	1.060	1.319	1.714	2.069	2.177	2.500	2.807	3.104	3.485	3.768
24	.685	.857	1.059	1.318	1.711	2.064	2.172	2.492	2.797	3.091	3.467	3.745
25	.684	.856	1.058	1.316	1.708	2.060	2.167	2.485	2.787	3.078	3.450	3.725
26	.684	.856	1.058	1.315	1.706	2.056	2.162	2.479	2.779	3.067	3.435	3.707
27	.684	.855	1.057	1.314	1.703	2.052	2.158	2.473	2.771	3.057	3.421	3.690
28	.683	.855	1.056	1.313	1.701	2.048	2.154	2.467	2.763	3.047	3.408	3.674
29	.683	.854	1.055	1.311	1.699	2.045	2.150	2.462	2.756	3.038	3.396	3.659
30	.683	.854	1.055	1.310	1.697	2.042	2.147	2.457	2.750	3.030	3.385	3.646
40	.681	.851	1.050	1.303	1.684	2.021	2.123	2.423	2.704	2.971	3.307	3.551
50	.679	.849	1.047	1.299	1.676	2.009	2.109	2.403	2.678	2.937	3.261	3.496
60	.679	.848	1.045	1.296	1.671	2.000	2.099	2.390	2.660	2.915	3.232	3.460
80	.678	.846	1.043	1.292	1.664	1.990	2.088	2.374	2.639	2.887	3.195	3.416
100	.677	.845	1.042	1.290	1.660	1.984	2.081	2.364	2.626	2.871	3.174	3.390
1000	.675	.842	1.037	1.282	1.646	1.962	2.056	2.330	2.581	2.813	3.098	3.300
∞	.674	.841	1.036	1.282	1.645	1.960	2.054	2.326	2.576	2.807	3.091	3.291
	50%	60%	70%	80%	90%	95%	96%	98%	99%	99.5%	99.8%	99.9%
	Confidence level C											

Table entry for p is the point (χ^2) with probability p lying above it.

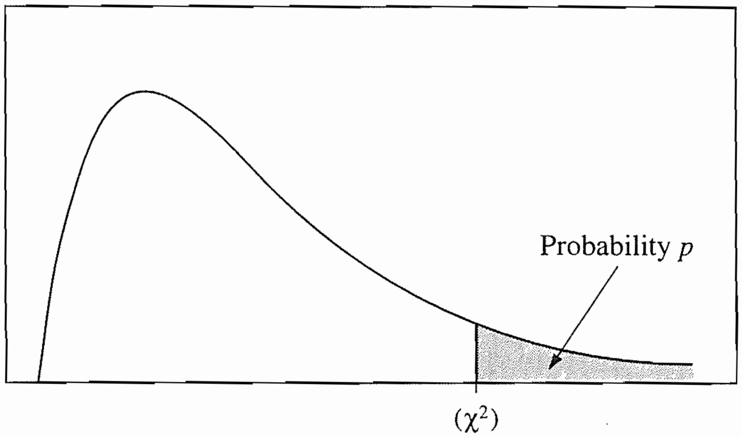


Table C χ^2 **critical values**

	Tail probability p											
df	.25	.20	.15	.10	.05	.025	.02	.01	.005	.0025	.001	.0005
1	1.32	1.64	2.07	2.71	3.84	5.02	5.41	6.63	7.88	9.14	10.83	12.12
2	2.77	3.22	3.79	4.61	5.99	7.38	7.82	9.21	10.60	11.98	13.82	15.20
3	4.11	4.64	5.32	6.25	7.81	9.35	9.84	11.34	12.84	14.32	16.27	17.73
4	5.39	5.99	6.74	7.78	9.49	11.14	11.67	13.28	14.86	16.42	18.47	20.00
5	6.63	7.29	8.12	9.24	11.07	12.83	13.39	15.09	16.75	18.39	20.51	22.11
6	7.84	8.56	9.45	10.64	12.59	14.45	15.03	16.81	18.55	20.25	22.46	24.10
7	9.04	9.80	10.75	12.02	14.07	16.01	16.62	18.48	20.28	22.04	24.32	26.02
8	10.22	11.03	12.03	13.36	15.51	17.53	18.17	20.09	21.95	23.77	26.12	27.87
9	11.39	12.24	13.29	14.68	16.92	19.02	19.68	21.67	23.59	25.46	27.88	29.67
10	12.55	13.44	14.53	15.99	18.31	20.48	21.16	23.21	25.19	27.11	29.59	31.42
11	13.70	14.63	15.77	17.28	19.68	21.92	22.62	24.72	26.76	28.73	31.26	33.14
12	14.85	15.81	16.99	18.55	21.03	23.34	24.05	26.22	28.30	30.32	32.91	34.82
13	15.98	16.98	18.20	19.81	22.36	24.74	25.47	27.69	29.82	31.88	34.53	36.48
14	17.12	18.15	19.41	21.06	23.68	26.12	26.87	29.14	31.32	33.43	36.12	38.11
15	18.25	19.31	20.60	22.31	25.00	27.49	28.26	30.58	32.80	34.95	37.70	39.72
16	19.37	20.47	21.79	23.54	26.30	28.85	29.63	32.00	34.27	36.46	39.25	41.31
17	20.49	21.61	22.98	24.77	27.59	30.19	31.00	33.41	35.72	37.95	40.79	42.88
18	21.60	22.76	24.16	25.99	28.87	31.53	32.35	34.81	37.16	39.42	42.31	44.43
19	22.72	23.90	25.33	27.20	30.14	32.85	33.69	36.19	38.58	40.88	43.82	45.97
20	23.83	25.04	26.50	28.41	31.41	34.17	35.02	37.57	40.00	42.34	45.31	47.50
21	24.93	26.17	27.66	29.62	32.67	35.48	36.34	38.93	41.40	43.78	46.80	49.01
22	26.04	27.30	28.82	30.81	33.92	36.78	37.66	40.29	42.80	45.20	48.27	50.51
23	27.14	28.43	29.98	32.01	35.17	38.08	38.97	41.64	44.18	46.62	49.73	52.00
24	28.24	29.55	31.13	33.20	36.42	39.36	40.27	42.98	45.56	48.03	51.18	53.48
25	29.34	30.68	32.28	34.38	37.65	40.65	41.57	44.31	46.93	49.44	52.62	54.95
26	30.43	31.79	33.43	35.56	38.89	41.92	42.86	45.64	48.29	50.83	54.05	56.41
27	31.53	32.91	34.57	36.74	40.11	43.19	44.14	46.96	49.64	52.22	55.48	57.86
28	32.62	34.03	35.71	37.92	41.34	44.46	45.42	48.28	50.99	53.59	56.89	59.30
29	33.71	35.14	36.85	39.09	42.56	45.72	46.69	49.59	52.34	54.97	58.30	60.73
30	34.80	36.25	37.99	40.26	43.77	46.98	47.96	50.89	53.67	56.33	59.70	62.16
40	45.62	47.27	49.24	51.81	55.76	59.34	60.44	63.69	66.77	69.70	73.40	76.09
50	56.33	58.16	60.35	63.17	67.50	71.42	72.61	76.15	79.49	82.66	86.66	89.56
60	66.98	68.97	71.34	74.40	79.08	83.30	84.58	88.38	91.95	95.34	99.61	102.7
80	88.13	90.41	93.11	96.58	101.9	106.6	108.1	112.3	116.3	120.1	124.8	128.3
100	109.1	111.7	114.7	118.5	124.3	129.6	131.1	135.8	140.2	144.3	149.4	153.2

STATISTICS

SECTION II

Time — 1 hour and 30 minutes
Number of problems — 6
Percent of total grade — 50

GENERAL INSTRUCTIONS

There are two parts to this section of the examination. Part A consists of five equally weighted problems that represent 75 percent of the total weight of this section. Spend about 65 minutes on this part of the exam. Part B consists of one longer problem that represents 25 percent of the total weight of this section. Spend about 25 minutes on this part of the exam. Since it is not expected that everyone will be able to complete all parts of all problems, you may wish to look over all the problems before you begin to work. The questions are printed in the booklet and on the green insert: it may be easier for you to look over all the problems on the insert. Statistical tables and useful formulas are printed in the green insert. When you are told to begin, open your booklet, carefully tear out the green insert, and start work.

- You should write all work for each part of each problem in the space provided for that part in this booklet. Be sure to write clearly and legibly. If you make an error, you may save time by crossing it out rather than trying to erase it. Erased or crossed-out work will not be graded. No credit will be given for any work shown on the green insert.

- Show all your work. Indicate clearly the methods you use because you will be graded on the correctness of your methods as well as the accuracy of your final answers. Correct answers without supporting work may not receive credit.

STATISTICS

SECTION II

Part A

Questions 1-5

Spend about 65 minutes on this part of the exam.

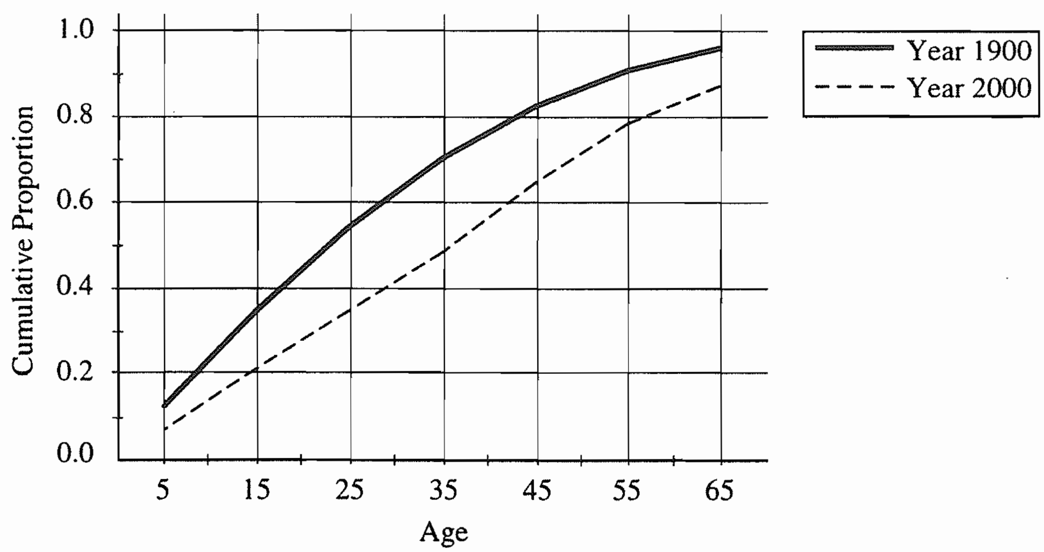
Percent of Section II grade—75

Show all your work. Indicate clearly the methods you use, because you will be graded on the correctness of your methods as well as on the accuracy of your results and explanation.

AGE DATA

Age	1900	2000
5	0.121	0.066
15	0.344	0.209
25	0.540	0.344
35	0.700	0.480
45	0.822	0.643
55	0.906	0.781
65	0.959	0.870

1. The table of data above provides the cumulative proportions for the United States population at selected ages for the years 1900 and 2000 (projected). For example, 0.344 or 34.4 percent of the population was at or under age 15 in 1900, while only 0.209 or 20.9 percent will be at or under age 15 in the year 2000. The graph below shows the cumulative proportions plotted against age for the years 1900 and 2000 (projected). The data and graph are to be used to compare the age distribution for the year 1900 with the projected age distribution for the year 2000.

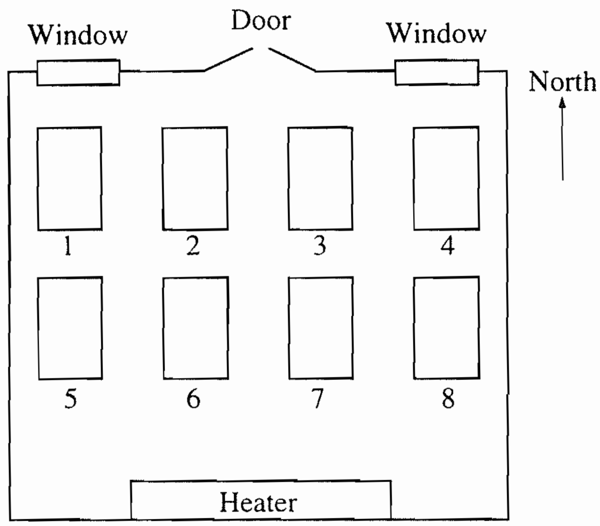


(a) Approximate the median age for each distribution.

(b) Approximate the interquartile range for each distribution.

(c) Using the results from parts (a) and (b), write a sentence or two for a history textbook comparing the age distributions for the years 1900 and 2000.

2. A new type of fish food has become available for salmon raised on fish farms. Your task is to design an experiment to compare the weight gain of salmon raised over a six-month period on the new and the old types of food. The salmon you will use for this experiment have already been randomly placed in eight large tanks in a room that has a considerable temperature gradient. Specifically, tanks on the north side of the room tend to be much colder than those on the south side. The arrangement of tanks is shown on the diagram below.



Describe a design for this experiment that takes account of the temperature gradient.

GO ON TO THE NEXT PAGE

3. A laboratory test for the detection of a certain disease gives a positive result 5 percent of the time for people who do not have the disease. The test gives a negative result 0.3 percent of the time for people who have the disease. Large-scale studies have shown that the disease occurs in about 2 percent of the population.

   (a) What is the probability that a person selected at random would test positive for this disease? Show your work.

   (b) What is the probability that a person selected at random who tests positive for the disease does not have the disease? Show your work.

GO ON TO THE NEXT PAGE

4. A random sample of 415 potential voters was interviewed 3 weeks before the start of a state-wide campaign for governor; 223 of the 415 said they favored the new candidate over the incumbent. However, the new candidate made several unfortunate remarks one week before the election. Subsequently, a new random sample of 630 potential voters showed that 317 voters favored the new candidate.

   Do these data support the conclusion that there was a decrease in voter support for the new candidate after the unfortunate remarks were made? Give appropriate statistical evidence to support your answer.

5. A company bakes computer chips in two ovens, oven A and oven B. The chips are randomly assigned to an oven and hundreds of chips are baked each hour. The percentage of defective chips coming from these ovens for each hour of production throughout a day is shown below.

Percentage of Defective Chips

Hour	Oven A	Oven B
1	45	36
2	32	37
3	34	33
4	31	34
5	35	33
6	37	32
7	31	33
8	30	30
9	27	24

The percentage of defective chips produced each hour by oven A has a mean of 33.56 and a standard deviation of 5.20. The percentage of defective chips produced each hour by oven B has a mean of 32.44 and a standard deviation of 3.78. The hourly differences in percentages for oven A minus oven B have a mean of 1.11 and a standard deviation of 4.28.

Does there appear to be a difference between oven A and oven B with respect to the mean percentages of defective chips produced? Give appropriate statistical evidence to support your answer.

STATISTICS

SECTION II

Part B

Question 6

Spend about 25 minutes on this part of the exam.

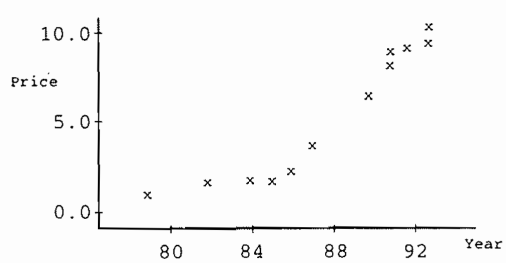
Percent of Section II grade—25

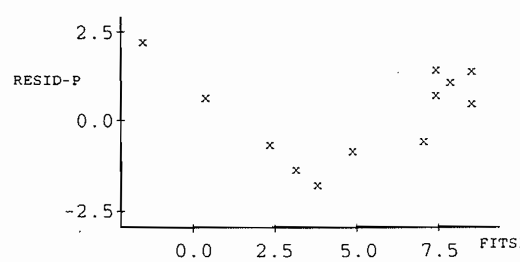
6. You are planning to sell a used 1988 automobile and want to establish an asking price that is competitive with that of other cars of the same make and model that are on the market. A review of newspaper advertisements for used cars yields the following data for 12 different cars of this make and model. You want to fit a least squares regression model to these data for use as a model in establishing the asking price for your car.

Production Year	1990	1991	1992	1987	1993	1991	1993	1985	1984	1982	1986	1979
Asking Price (in thousands of dollars)	6.0	7.7	8.8	3.4	9.8	8.4	8.9	1.5	1.6	1.4	2.0	1.0

The computer printouts for three different linear regression models are shown below. Model 1 fits the asking price as a function of the production year, Model 2 fits the natural logarithm of the asking price as a function of the production year, and Model 3 fits the square root of the asking price as a function of the production year. Each printout also includes a plot of the residuals from the linear model *versus* the fitted values, as well as additional descriptive data produced from the least squares procedure.

Model 1





The regression equation is
Price = -58.1 + 0.719 Year.

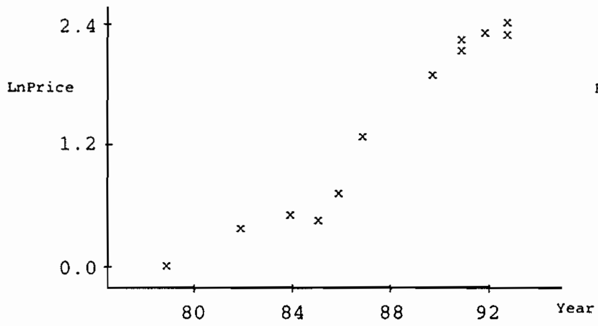
Predictor	Coef	Stdev	t-ratio	p
Constant	-58.050	7.205	-8.06	0.000
Year	0.71900	0.08200	8.77	0.000

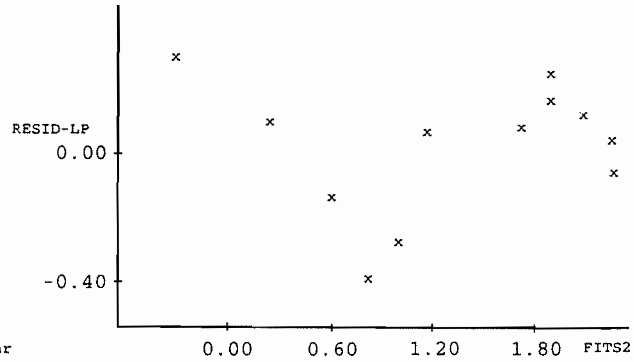
s = 1.255 R-sq = 88.5%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	1	121.10	121.10	76.88	0.000
Error	10	15.75	1.58		
Total	11	136.85			

Model 2





The regression equation is
LnPrice = -14.9 + 0.185 Year.

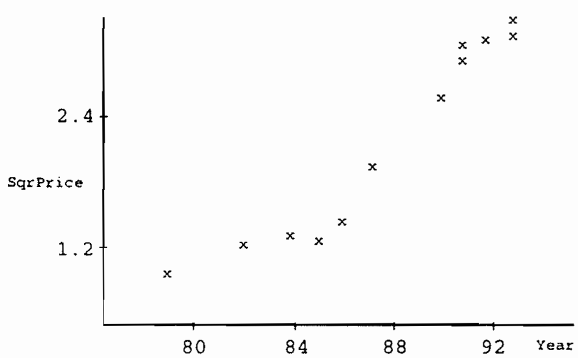
Predictor	Coef	Stdev	t-ratio	p
Constant	-14.924	1.223	-12.21	0.000
Year	0.18502	0.01392	13.30	0.000

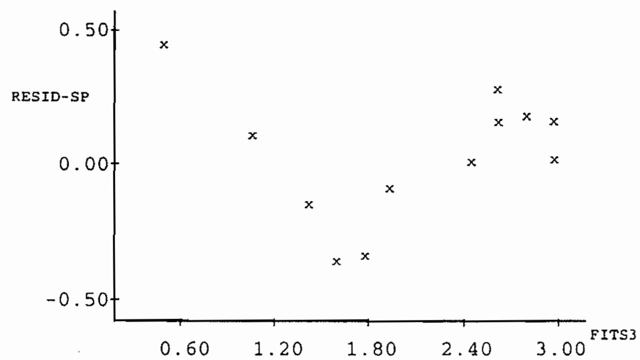
s = 0.2130   R-sq = 94.6%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	1	8.0190	8.0190	176.77	0.000
Error	10	0.4536	0.0454		
Total	11	8.4726			

Model 3





The regression equation is
SqrPrice = -13.3 + 0.176 Year.

Predictor	Coef	Stdev	t-ratio	p
Constant	-13.313	1.447	-9.20	0.000
Year	0.17559	0.01647	10.66	0.000

s = 0.2520   R-sq = 91.9%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	1	7.2221	7.2221	113.72	0.000
Error	10	0.6351	0.0635		
Total	11	7.8572			

(a) Use Model 1 to establish an asking price for your 1988 automobile.

(b) Use Model 2 to establish an asking price for your 1988 automobile.

(c) Use Model 3 to establish an asking price for your 1988 automobile.

(d) Describe any shortcomings you see in these three models.

(e) Use some or all of the given data to find a better method for establishing an asking price for your 1988 automobile. Explain why your method is better.

If you need more room for your work, use the space below.

END OF EXAMINATION

Chapter III Answers to the 1997 AP Statistics Examination

- Section I: Multiple Choice
  - Blank Answer Sheet
- Section II: Free Response
  - Student Preparation for the Exam
  - Free-Response Questions, Scoring Guidelines, and Sample Student Responses
  - Section II, Part A
  - Section II, Part B

Section I: Multiple Choice

Listed below are the correct answers to the multiple-choice questions and the percentage of AP candidates who answered each question correctly. A copy of the blank answer sheet appears on the following pages for reference.

Section I Answer Key and Percent Answering Correctly

Item No.	Correct Answer	Percent Correct	Item No.	Correct Answer	Percent Correct	Item No.	Correct Answer	Percent Correct
1	E	88%	13	B	73%	25	C	65%
2	D	81%	14	D	73%	26	C	55%
3	C	75%	15	B	83%	27	E	82%
4	D	93%	16	E	69%	28	B	55%
5	A	73%	17	B	74%	29	A	60%
6	A	68%	18	E	63%	30	A	46%
7	B	61%	19	E	91%	31	A	69%
8	B	80%	20	C	36%	32	D	42%
9	D	80%	21	B	69%	33	C	30%
10	B	87%	22	A	56%	34	A	53%
11	B	74%	23	A	68%	35	C	65%
12	D	76%	24	B	70%			

AREA 1 – COMPLETE THIS AREA AT EVERY EXAMINATION.

PLACE AP® NUMBER LABEL HERE.

A. SIGNATURE

To maintain the security of the exam and the validity of my AP grade, I will allow no one other than myself to see the multiple-choice questions and will seal the appropriate section when asked to do so. In addition, I am aware of and agree to the Program's policies and procedures as outlined in the 1998 *AP Bulletin for Students and Parents.*

Sign your name as it will appear on your college applications.

B. YOUR AP NUMBER

C. NAME Omit spaces, hyphens, apostrophes, Jr. or II.

Last Name - first 15 letters | First Name - first 12 letters | MI

D. ADMIN. DAY IN MAY

E. TIME OF DAY

6 AM, 7 AM, 8 AM, 9 AM, 10 AM, 11 AM, 12 PM, 1 PM, 2 PM, 3 PM, 4 PM, 5 PM

F. AP EXAMINATION TO BE TAKEN USING THIS ANSWER SHEET

Print examination name: Statistics

Fill in the appropriate oval below for examination name and number.

07	U.S. History	55	German Language
13	Art: History of	57	Gov. & Pol.: **U.S.**
14	Art: Studio Drawing	58	Gov. & Pol.: **Comp.**
15	Art: Studio General	59	International English Language
20	Biology	60	Latin: Vergil
25	Chemistry	60	Latin: Literature
31	Computer Science A	66	Calculus AB
33	Computer Science AB	68	Calculus BC
34	Economics: **Micro**	75	Music Theory
35	Economics: **Macro**	78	Physics B
36	Eng. Language & Comp.	80	Physics C: **Mech.**
37	Eng. Literature & Comp.	80	Physics C: **E & M**
40	Environmental Science	85	Psychology
43	European History	87	Spanish Language
48	French Language	89	Spanish Literature
51	French Literature	90	Statistics

G. What language do you know best?

- English
- English and another language about the same
- Another language

H. DO NOT COMPLETE THIS SECTION UNLESS INSTRUCTED TO DO SO.

Essay Choices

Fill in the ovals under the numbers of the essay questions you answered in this examination.

1 2 3 4 5 6 7 8 9 10 11 12

SCHOOL USE ONLY

Fee Reduction Granted | Report to Teachers Section Designation 1 2 3 4 5 6 7 8 9

I.N. 240045 18002 • 00657 • TF18M1300 Q2800-06 CHW97329 1 2 3 4

Answer Sheet for May 1997, Form 3TBP

Advanced Placement Program®

THE COLLEGE BOARD

AREA 2 – COMPLETE THIS AREA ONLY ONCE.

I. SEX

1 Male
2 Female

J. PRESENT GRADE LEVEL

1 9th grade
2 10th grade
3 11th grade
4 12th grade
5 College
6 Other

K. DATE OF BIRTH

Month | Day | Year

01 Jan., 02 Feb., 03 Mar., 04 Apr., 05 May, 06 June, 07 July, 08 Aug., 09 Sept., 10 Oct., 11 Nov., 12 Dec.

L. SOCIAL SECURITY NUMBER

M. ETHNIC GROUP

1 American Indian or Alaskan native
2 Black or African American
3 Mexican American or Chicano
4 Asian, Asian American, or Pacific Islander
5 Puerto Rican
6 South American, Latin American, Central American, or other Hispanic
7 White
8 Other

N. EXPECTED DATE OF COLLEGE ENTRANCE

F Fall
W Winter/Spring
S Summer
U Undecided

8 1998
9 1999
0 2000
1 2001

O. Will you be applying for Sophomore Standing at college?

Yes No

ETS USE ONLY

Exam 1 2 | Exam 1 2

P. STUDENT SEARCH SERVICE OF THE COLLEGE BOARD
(Complete ONLY if you are a SOPHOMORE or a JUNIOR.)

- Yes, I want the College Board to send information about me to colleges, universities, and governmental scholarship programs interested in students like me.
- No, I do not want the College Board to send information about me to colleges, universities, and governmental scholarship programs through the Student Search Service.

Q. THIS SECTION IS FOR THE SURVEY QUESTIONS IN THE CANDIDATE PACK. (DO NOT PUT RESPONSES TO EXAM QUESTIONS IN THIS SECTION.) BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL.

1	A	B	C	D	E	4	A	B	C	D	E
2	A	B	C	D	E	5	A	B	C	D	E
3	A	B	C	D	E						

DO NOT COMPLETE THIS SECTION UNLESS INSTRUCTED TO DO SO.

R. If this answer sheet is for the French Language, French Literature, German Language, Spanish Language, or Spanish Literature Examination, please answer the following questions. (Your responses will not affect your grade.)

1. Have you lived or studied for one month or more in a country where the language of the exam you are now taking is spoken? ◯ Yes ◯ No
2. Do you regularly speak or hear the language at home? ◯ Yes ◯ No

INDICATE YOUR ANSWERS TO THE EXAM QUESTIONS IN THIS SECTION. IF A QUESTION HAS ONLY FOUR ANSWER OPTIONS, DO NOT MARK OPTION (E). YOUR ANSWER SHEET WILL BE SCORED BY MACHINE. USE ONLY NO. 2 PENCILS TO MARK YOUR ANSWERS ON PAGES 2 AND 3 (ONE RESPONSE PER QUESTION). AFTER YOU HAVE DETERMINED YOUR RESPONSE, BE SURE TO COMPLETELY FILL IN THE OVAL CORRESPONDING TO THE NUMBER OF THE QUESTION YOU ARE ANSWERING. STRAY MARKS AND SMUDGES COULD BE READ AS ANSWERS, SO ERASE CAREFULLY AND COMPLETELY. ANY IMPROPER GRIDDING MAY AFFECT YOUR GRADE.

1	A	B	C	D	E	26	A	B	C	D	E	51	A	B	C	D	E
2	A	B	C	D	E	27	A	B	C	D	E	52	A	B	C	D	E
3	A	B	C	D	E	28	A	B	C	D	E	53	A	B	C	D	E
4	A	B	C	D	E	29	A	B	C	D	E	54	A	B	C	D	E
5	A	B	C	D	E	30	A	B	C	D	E	55	A	B	C	D	E
6	A	B	C	D	E	31	A	B	C	D	E	56	A	B	C	D	E
7	A	B	C	D	E	32	A	B	C	D	E	57	A	B	C	D	E
8	A	B	C	D	E	33	A	B	C	D	E	58	A	B	C	D	E
9	A	B	C	D	E	34	A	B	C	D	E	59	A	B	C	D	E
10	A	B	C	D	E	35	A	B	C	D	E	60	A	B	C	D	E
11	A	B	C	D	E	36	A	B	C	D	E	61	A	B	C	D	E
12	A	B	C	D	E	37	A	B	C	D	E	62	A	B	C	D	E
13	A	B	C	D	E	38	A	B	C	D	E	63	A	B	C	D	E
14	A	B	C	D	E	39	A	B	C	D	E	64	A	B	C	D	E
15	A	B	C	D	E	40	A	B	C	D	E	65	A	B	C	D	E
16	A	B	C	D	E	41	A	B	C	D	E	66	A	B	C	D	E
17	A	B	C	D	E	42	A	B	C	D	E	67	A	B	C	D	E
18	A	B	C	D	E	43	A	B	C	D	E	68	A	B	C	D	E
19	A	B	C	D	E	44	A	B	C	D	E	69	A	B	C	D	E
20	A	B	C	D	E	45	A	B	C	D	E	70	A	B	C	D	E
21	A	B	C	D	E	46	A	B	C	D	E	71	A	B	C	D	E
22	A	B	C	D	E	47	A	B	C	D	E	72	A	B	C	D	E
23	A	B	C	D	E	48	A	B	C	D	E	73	A	B	C	D	E
24	A	B	C	D	E	49	A	B	C	D	E	74	A	B	C	D	E
25	A	B	C	D	E	50	A	B	C	D	E	75	A	B	C	D	E

FOR QUESTIONS 76-151, SEE PAGE 3.

DO NOT WRITE IN THIS AREA.

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL. IF A QUESTION HAS ONLY FOUR ANSWER OPTIONS, DO NOT MARK OPTION E.

76	A	B	C	D	E	101	A	B	C	D	E	126	A	B	C	D	E
77	A	B	C	D	E	102	A	B	C	D	E	127	A	B	C	D	E
78	A	B	C	D	E	103	A	B	C	D	E	128	A	B	C	D	E
79	A	B	C	D	E	104	A	B	C	D	E	129	A	B	C	D	E
80	A	B	C	D	E	105	A	B	C	D	E	130	A	B	C	D	E
81	A	B	C	D	E	106	A	B	C	D	E	131	A	B	C	D	E
82	A	B	C	D	E	107	A	B	C	D	E	132	A	B	C	D	E
83	A	B	C	D	E	108	A	B	C	D	E	133	A	B	C	D	E
84	A	B	C	D	E	109	A	B	C	D	E	134	A	B	C	D	E
85	A	B	C	D	E	110	A	B	C	D	E	135	A	B	C	D	E
86	A	B	C	D	E	111	A	B	C	D	E	136	A	B	C	D	E
87	A	B	C	D	E	112	A	B	C	D	E	137	A	B	C	D	E
88	A	B	C	D	E	113	A	B	C	D	E	138	A	B	C	D	E
89	A	B	C	D	E	114	A	B	C	D	E	139	A	B	C	D	E
90	A	B	C	D	E	115	A	B	C	D	E	140	A	B	C	D	E
91	A	B	C	D	E	116	A	B	C	D	E	141	A	B	C	D	E
92	A	B	C	D	E	117	A	B	C	D	E	142	A	B	C	D	E
93	A	B	C	D	E	118	A	B	C	D	E	143	A	B	C	D	E
94	A	B	C	D	E	119	A	B	C	D	E	144	A	B	C	D	E
95	A	B	C	D	E	120	A	B	C	D	E	145	A	B	C	D	E
96	A	B	C	D	E	121	A	B	C	D	E	146	A	B	C	D	E
97	A	B	C	D	E	122	A	B	C	D	E	147	A	B	C	D	E
98	A	B	C	D	E	123	A	B	C	D	E	148	A	B	C	D	E
99	A	B	C	D	E	124	A	B	C	D	E	149	A	B	C	D	E
100	A	B	C	D	E	125	A	B	C	D	E	150	A	B	C	D	E
												151	A	B	C	D	E

ETS USE ONLY

	R	W	FS
PT1			
PT2			
PT3			
PT4			
TOT			
EQ			
TA1			
TA2			

DO NOT WRITE IN THIS AREA.

AREA 3 – COMPLETE THIS AREA ONLY ONCE.

1. YOUR MAILING ADDRESS

- YOUR GRADE REPORT WILL BE MAILED TO THIS ADDRESS IN JULY.
- USING THE ABBREVIATIONS GIVEN IN YOUR CANDIDATE PACK, FILL ADDRESS INTO BOXES PROVIDED. IF YOUR ADDRESS DOES NOT FIT, SEE ITEM 2 BELOW.
- INDICATE A SPACE IN YOUR ADDRESS BY LEAVING A BLANK BOX AND FILLING IN THE CORRESPONDING DIAMOND (◇) BELOW THE BOX.

Street

City

STATE

1	AL	28	NE
2	AK	29	NV
3	AZ	30	NH
4	AR	31	NJ
5	CA	32	NM
6	CO	33	NY
7	CT	34	NC
8	DE	35	ND
9	DC	36	OH
10	FL	37	OK
11	GA	38	OR
12	HI	39	PA
13	ID	40	RI
14	IL	41	SC
15	IN	42	SD
16	IA	43	TN
17	KS	44	TX
18	KY	45	UT
19	LA	46	VT
20	ME	47	VA
21	MD	48	WA
22	MA	49	WV
23	MI	50	WI
24	MN	51	WY
25	MS	52	Puerto Rico
26	MO		
27	MT	53	Other

ZIP OR POSTAL CODE

1a. COUNTRY CODE

3. TELEPHONE NUMBER

Area Code

2. If the address gridded above is not complete enough for delivery of your grade report, please fill in this oval → ◯ and print your complete address below.

Address

Address

City

State or Province

Country

Zip or Postal Code

4. SCHOOL YOU ATTEND

School Code

School Name, City, and State

← Make sure you have correctly entered your School Code and filled in the appropriate ovals.

School Name

City

State

5. COLLEGE TO RECEIVE YOUR AP GRADES

College Code

College Name and Address

Using the College Code list in the AP Candidate Pack, indicate the one college that has *accepted you* and that *you plan to attend.*

College Name

City

State

Section II: Free Response

Student Preparation for the Exam

The free-response questions, for the most part, intentionally gave little direction as to how the student was to approach the problem and the rubrics were designed to give credit for any correct method. However, for inference problems the rubrics required students to explain the method used along with the assumptions for the method, and to look carefully at the data to see if they thought the assumptions were satisfied. The analysis had to be followed by a clearly stated correct conclusion, written in the context of the original question.

Many students had difficulty determining what method to use, often trying two or three approaches or mixing approaches in ways that were unclear to the faculty consultants at the Reading. In addition, students had difficulty explaining assumptions and rarely looked at the data to see if assumptions were satisfied. Conclusions were often poorly written both in terms of the statistical concepts and the grammar. Students must learn to view statistical inference as a process that involves five steps:

1) understanding the problem to be solved,
2) finding an appropriate method,
3) checking the assumptions for the method against all the available data,
4) carrying out the analysis, and
5) writing a clear and correct conclusion in the context of the original problem.

Student preparation on the basic principles of blocking and randomization for designed studies was also quite weak. For question 2, on the design of an experiment, many students appeared to be confused about what constituted the treatments and what constituted the experimental units. Among those who seemed to grasp this idea, many did not understand that blocking is the best way to reduce variation among the experimental units or got confused about how to block appropriately. In addition, many did not understand that randomization is necessary to reduce bias and to allow probability-based methods of analysis to be used after the data are collected.

In summary, the examination contained a fairly easy multiple-choice section and a challenging free-response section. The questions in the latter appeared to be fair, in light of the Course Description, but many students were not adequately prepared to explain and defend methods used and to write clear conclusions reflecting both good statistics and good writing.

Free-Response Questions, Scoring Guidelines, and Sample Student Responses

The answers presented here are actual student responses to the six free-response questions on the 1997 AP Statistics Examination. The students gave permission to have their work reproduced at the time they took the exam. These responses were read and scored by the leaders and faculty consultants assigned to each particular question and were used as sample responses for the training of faculty consultants during the AP Reading in June 1997. The actual scores that these students received, as well as a brief explanation of why, are indicated.

Question 1 Scoring Guidelines

4 Complete Response

Correctly uses the graph or (informally) interpolates in the table to approximate the medians and quartiles. The numerical values must make practical sense within the context of the problem.

Approximates medians for 1900 to be about 23 or 24 and for 2000 about 35 or 36.

Approximates the interquartile ranges for 1900 to be about 40 - 12 = 28 and for 2000 about 54 - 18 = 36.

May not calculate the IQR but gives a clear indication in the writing that the distance between the quartiles is a measure of spread.

States clearly that the U.S. age distribution will shift toward larger values for 2000 as compared to 1900, with greater variability in 2000. The statement is consistent with the numerical results from parts (a) and (b) and is written in such a way that it would be understood by the general population.

3 Substantial Response

Approximates medians and interquartile ranges nearly correctly from the graph or the table. Need not calculate the IQR if there is some indication that the quartiles can measure variability.

States clearly that the U.S. age distribution will shift toward larger values for 2000 as compared to 1900, but may not specifically mention the increase in variability.

2 Developing Response

Gives a poor approximation for the medians or interquartile ranges, but seems to have some understanding of what these measures represent.

Or, provides at least a weak but correct statement on the nature of the changing populations.

1 Minimal Response

Indicates some understanding of at least one of the three parts of the question.

Sample 1

(a) **Approximate the median age for each distribution.**

1900

$15 < \text{median age} < 25$

median age ≈ 22.5 yrs

2000

$35 < \text{median age} < 45$

median age ≈ 36 yrs

(b) Approximate the interquartile range for each distribution.

1900

.25 .75

10-11 ≤ x ≤ 39

size

39 − 11 = $\boxed{28 \text{ yrs}}$

$\boxed{11 \Rightarrow 39}$

values

2000

.25 .75

18 ≤ x ≤ 53 ← values

53−18 = $\boxed{35 \text{ yrs}}$ size

(c) Using the results from parts (a) and (b), write a sentence or two for a history textbook comparing the age distributions for the years 1900 and 2000.

At the turn of the century in 1900, the age of people was much lower than it will be when we hit the year 2000. In 1900 the median age was only 22 to 23 years old while in the year 2000 it will be about 36. People are living longer now. The middle 50% of people in 1900 were between 11 and 39 years old while in 2000 the middle 50% will be between 18 and 53 years old.

Commentary:

The medians and interquartile ranges are clearly specified for both the 1900 and 2000 data. The student describes the shift toward an older population in 2000 by stating how the median increases and how the spread of the middle 50% also increases. *Score = 4*

Sample 2

(a) Approximate the median age for each distribution.

The median age for each distribution would appear at the age where 50% of the population was at or below that age. In the case of 1900, the approx. median age was close to 25 yrs. of age, with 54.4% of the population being at or below the age of 25. For the 2000 distribution the approx. median age was slightly above 35 yrs., with ~48% of the population at or below the age of 35.

(b) Approximate the interquartile range for each distribution.

The interquartile range is equivalent to the range of the ages in the middle 50% of each population distribution. This it can be found by subtracting the 25% age (approx.) from the 75% age (approx.)

estimated from graph...

1900: approx. 25% - 12 yrs. → 40 yrs - 12 yrs = 28 yrs..
approx. 75% - 40 yrs.

2000: approx. 25% 20 yrs. → 55 yrs - 20 yrs = 35 yrs.
approx. 75% - 55 yrs..

The approx. IQR for 1900 is 28 yrs., while for 2000, it is 35 yrs.

(c) Using the results from parts (a) and (b), write a sentence or two for a history textbook comparing the age distributions for the years 1900 and 2000.

In the year 2000, the population, as a whole will be older than it was in the year 1900, as can be based on the medians. The spread of the population ages, will also be fairly different as is demonstrated by the IQRs. In the year 2000, the ages of the population will be spread more widely relative to the population in 1900.

Commentary:

The thinking of this student is clearly stated in words; the reasoning on both the medians and the interquartile ranges is correct. The conclusion concisely states how both the center and spread of the ages increase between 1900 and 2000. *Score = 4*

Sample 3

(a) **Approximate the median age for each distribution.**

The median age for the population of 1900 lies between the ages of 15 and 25, where 50% of the population is above & below the median. This age is contained in (15, 25), roughly 23.

The median age for the 2000 population lies between the ages of 35 and 45, roughly 37.

(b) **Approximate the interquartile range for each distribution.**

The IQR is $Q_3 - Q_1$. For 1900, $Q_3 \approx 37$ and $Q_1 \approx 10$. Therefore, the IQR $\approx$ 27 years

For 2000, $Q_3 \approx 53$ and $Q_1 \approx 17$. Therefore, the IQR $\approx$ 36 years

(c) **Using the results from parts (a) and (b), write a sentence or two for a history textbook comparing the age distributions for the years 1900 and 2000.**

During the year 1900, the majority of the U.S. population ranged from the ages of 10 to 37, while in the year 2000, the population ranged from 17 to 53 years old. In general, the age of the "average" American citizen has increased dramatically.

Commentary:

Correct reasoning and good approximations are provided for both the medians and the interquartile ranges. Although the conclusion states that ages are increasing, the use of interquartile ranges to express this idea is a bit confused. Both the "majority" and "population ranged" terms are not quite correct. *Score = 3*

4 Complete Response

Shows four blocks of two tanks each, with the pairs of tanks being in nearly identical conditions with regard to temperature. The blocks are (1,4), (2,3), (5,8), and (6,7).

States clearly that this is the potentially most effective arrangement of blocks since these pairs should be the most homogeneous.

Explains a correct method for randomly assigning treatments to blocks.

3 Substantial Response

Shows two blocks of four tanks each which take into account the north-south temperature gradient. The blocks are (1,2,3,4) and (5,6,7,8).

Or, shows four blocks of two tanks each which take into account the north-south temperature gradient. These blocks are (1,2), (3,4), (5,6), and (7,8).

Or, shows a correct design for the case in which **both** foods could be used in each tank.

Explains a method of randomly assigning the two treatments to tanks that shows some understanding of randomization.

2 Developing Response

Shows a design that correctly takes temperature into account, but ignores the randomization.

Or, explains a method of randomly assigning the two treatments to tanks and indicates that temperature is to be taken into account in the analysis.

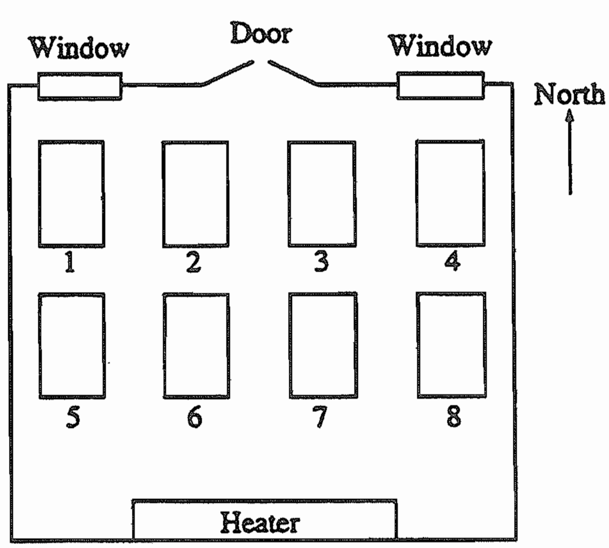
1 Minimal Response

Shows some knowledge of what is meant by blocks, but is not clear on any rationale for choosing blocks or any method of assigning treatments.

Or, states that the two treatments must be randomly assigned to tanks but ignores the temperature gradient.

Sample 1

2. A new type of fish food has become available for salmon raised on fish farms. Your task is to design an experiment to compare the weight gain of salmon raised over a six-month period on the new and the old types of food. The salmon you will use for this experiment have already been randomly placed in eight large tanks in a room that has a considerable temperature gradient. Specifically, tanks on the north side of the room tend to be much colder than those on the south side. The arrangement of tanks is shown on the diagram below.



Describe a design for this experiment that takes account of the temperature gradient.

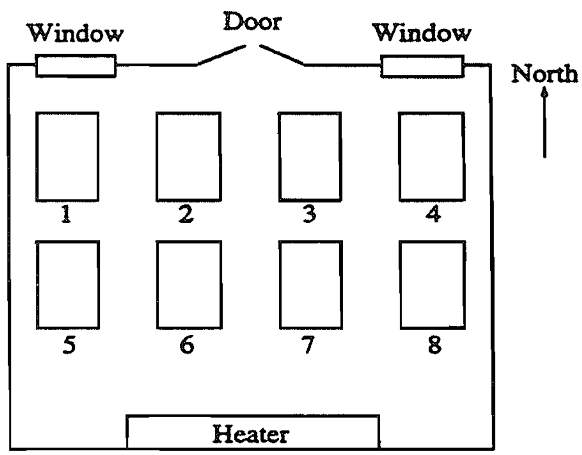
Because of the room's symmetry, it is possible to match each tank with another that should have very similar, if not equal temperatures. The matchings are 1, 4 2, 3 5, 8 and 6, 7. From each pair, choose one tank to be fed with the new food and one tank to be fed with the old food. This choice should be done randomly (possibly by the toss of a coin). At both the beginning and end of the six week period, find mean weight of the fish on each type of food. Then calculate the difference in weight gain and determine if it is significant.

Commentary:

The idea of pairing similar tanks to form homogeneous blocks is clearly stated, as is the notion of randomly assigning treatments to the tanks within a block. It is not necessary to discuss the analysis of the resulting data in any detail. *Score = 4*

Sample 2

2. A new type of fish food has become available for salmon raised on fish farms. Your task is to design an experiment to compare the weight gain of salmon raised over a six-month period on the new and the old types of food. The salmon you will use for this experiment have already been randomly placed in eight large tanks in a room that has a considerable temperature gradient. Specifically, tanks on the north side of the room tend to be much colder than those on the south side. The arrangement of tanks is shown on the diagram below.



Describe a design for this experiment that takes account of the temperature gradient.

To account for the temp. gradient, the salmon should be divided into the following groups:

1 + 4
5 + 8
2 + 3
6 + 7

Each fish in these group would be in the relatively same temp. environment as the other fish in the group, based on room location.

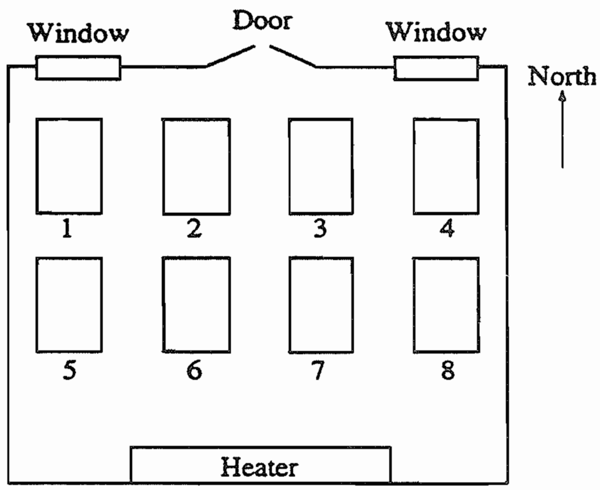
You would now randomly assign 1 fish in each group the new food, and give the other fish the old food. After 6 months, compare the weight gain of each fish in each group. Any differences in the weight gain would have to be attributed to the new food, since temperature differences have been neutralized.

Commentary:

In this response, the block arrangement for tanks is chosen correctly and randomization is used properly. The conclusion is a clear statement on the purpose of blocking and randomization, showing that the student understands the basic principle. *Score = 4*

Sample 3

2. A new type of fish food has become available for salmon raised on fish farms. Your task is to design an experiment to compare the weight gain of salmon raised over a six-month period on the new and the old types of food. The salmon you will use for this experiment have already been randomly placed in eight large tanks in a room that has a considerable temperature gradient. Specifically, tanks on the north side of the room tend to be much colder than those on the south side. The arrangement of tanks is shown on the diagram below.



Describe a design for this experiment that takes account of the temperature gradient.

The room would be divided into two blocks. Two block would be of tanks 1, 2, 3, and 4 on the north side of the room The other would be of tanks 5, 6, 7 and 8 on the south side of the room. Starting with tanks 1 and 4, each tank in each block will be randomly assigned either new or old food. Only 2 tanks in each block can receive the same type of food. Therefore, after two of the same types are assigned in a block the other one or two tanks will receive the remaining unused treatment. The fish will be fed once a day and checked for weight gain once every 2 weeks. At the end of the six-month period, they will again be checked for weight gain and the results will be assessed

Commentary:

Next to the four blocks of two tanks seen on previous responses, this is the second best blocking arrangement. The student correctly explains how randomization will be used. *Score* = 3.

Question 3 Scoring Guidelines

4 Complete Response

Either by formula or by constructing a table or tree diagram, demonstrates understanding of the three pieces of information given in the problem.

P(positive | no disease) = .05
P(negative | disease) = .003
P(disease) = .02

a. Correctly reworks that conditional information to answer the unconditional probability as

$$P(\text{positive}) = P(\text{disease})*P(\text{positive} \mid \text{disease}) + P(\text{no disease})*P(\text{positive} \mid \text{no disease})$$
$$= (.02)(.997) + (.98)(.05) = .0689$$

b. Correctly reworks that conditional information to answer the conditional probability as

$$P(\text{no disease} \mid \text{positive}) = \frac{P(\text{positive} \mid \text{no disease})P(\text{no disease})}{P(\text{positive})}$$

$$= \frac{(.05)(.98)}{.0689} = .7112$$

May have minor errors in arithmetic or decimal conversions, but the reasoning is correct throughout. The following tree diagram or table may be used to show the structure of the problem.

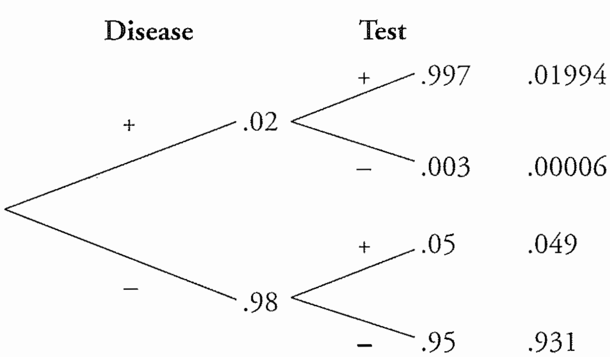


Table of Expected Cell Sizes for a Population of 100

	Disease +	Disease –	Totals
Test +	1.994	4.9	6.894
Test –	.006	93.1	93.106
Totals	2	98	100

P(positive test) = 6.894 / 100 = .0689
P(no disease | positive test) = 4.9 / 6.894 = .7108

3 Substantial Response

Either by formula or by constructing a table or tree diagram, demonstrates understanding of the three pieces of information given in the problem. Reasons through both parts correctly but may have misread the data in the problem or have errors in arithmetic (e.g., correctly reasons through part a and uses the result in the denominator for the solution to part b but uses incorrect product in the numerator).

2 Developing Response

Reasons through one of parts a or b correctly, but not the other. May have errors in arithmetic.

1 Minimal Response

Shows some understanding of what is being asked for, but does not correctly reason through either part of the problem [e.g., understands the conditional information given or attempts to find P(no disease | positive) or P(positive)].

Sample 1

3. A laboratory test for the detection of a certain disease gives a positive result 5 percent of the time for people who do not have the disease. The test gives a negative result 0.3 percent of the time for people who have the disease. Large-scale studies have shown that the disease occurs in about 2 percent of the population.

   (a) What is the probability that a person selected at random would test positive for this disease? Show your work.

P(HAVE DISEASE AND POSITIVE RESULT) OR P(DON'T HAVE DISEASE AND POS. RESULT

$$(.02)(.997) + (.98)(.05) = .06894$$

.06894 IS THE PROBABILITY OF TESTING POSITIVE

   (b) What is the probability that a person selected at random who tests positive for the disease does not have the disease? Show your work.

$$P(\text{DOES NOT HAVE DISEASE} \mid \text{POSITIVE RESULT}) = \frac{P(\text{DOESN'T HAVE DISEASE + POSITIVE})}{P(\text{POSITIVE RESULT})}$$

$$= \frac{(.98)(.05)}{.06894}$$

$$= .71076$$

.71076 IS THE PROBABILITY A PERSON TESTS POSITIVE AND DOES NOT HAVE A DISEASE.

Commentary:

The tree diagram shows that the student understands the structure of the problem. The additive and multiplicative rules of probability are used correctly in (a) and conditional probability is assessed correctly in (b). *Score = 4*

Sample 2

3. A laboratory test for the detection of a certain disease gives a positive result 5 percent of the time for people who do not have the disease. The test gives a negative result 0.3 percent of the time for people who have the disease. Large-scale studies have shown that the disease occurs in about 2 percent of the population.

   (a) What is the probability that a person selected at random would test positive for this disease? Show your work.

The person can either have it & test positive or not have it and test positive!

P(has disease) = 0.02   P(no disease) = 0.98

↓   ↓

shows positive 100-0.3 or 99.7% of time   Shows pos. 5% of time

$P(\text{positive}) = 0.02 \times 0.997 + 0.98 \times 0.05 = \boxed{0.069}$

   (b) What is the probability that a person selected at random who tests positive for the disease does not have the disease? Show your work.

This is $\dfrac{P(\text{no disease}) \cup P(\text{show pos.})}{P(\text{disease}) \cup P(\text{show pos.}) + P(\text{no disease}) \cup P(\text{show pos})}$

$= \dfrac{0.98 \times 0.05}{0.02 \times 0.997 + 0.98 \times 0.05} = \boxed{0.711}$

This means that 71.1% of people who test positive for the disease do not have it.. quite a high percentage, but not really avoidable

Commentary:

The student writes out the structure of the events under consideration, thereby showing an understanding of the structure of the problem. The rules of probability are used correctly throughout. *Score = 4*

Sample 3

3. A laboratory test for the detection of a certain disease gives a positive result 5 percent of the time for people who do not have the disease. The test gives a negative result 0.3 percent of the time for people who have the disease. Large-scale studies have shown that the disease occurs in about 2 percent of the population.

(a) What is the probability that a person selected at random would test positive for this disease? Show your work.

Out of 100 people, 2 on average have the disease, who will give positive results 99.7% of the time. 98 people who don't have the disease (on average) will test positive 5% of the time.

Out of 100 people, the probability of testing positive is

$$\frac{2 \cdot 0.997 + 98 \cdot 0.05}{100} = 0.069$$

(b) What is the probability that a person selected at random who tests positive for the disease does not have the disease? Show your work.

$$p(\text{not have the disease} \mid \text{test positive for disease}) = \frac{p(\text{not have disease } \underline{\text{and}} \text{ test pos.})}{p(\text{test positive})}$$

$$= \frac{0.05}{0.069} = 0.725$$

Commentary:

This student correctly assesses what will happen to a typical group of 100 people in (a), but forgets to multiply the numerator in (b) by the probability of not having the disease. *Score = 3*

4 Complete Response

Recognizes that the problem involves a significance test on the difference between two proportions. Recognizes that the large sample approximation procedure is justified. Sets up correct hypotheses, including a one-sided alternative, with explanations of notation; i.e., enough information is provided to identify symbols with groups.

Identifies and correctly evaluates an appropriate test statistic. The test statistic may be standard normal with either the pooled or unpooled version of the standard error. The test statistic is approximately equivalent for both, z = 1.08. The chi-square value is 1.17; the 95% large sample confidence interval for the difference between the two proportions is (–0.028, 0.096).

May make trivial arithmetic errors.

Finds the p-value (or critical value) that is consistent with α, H_a, etc.

States what the significance test allows one to conclude with regard to the original question, using the obtained p-value correctly. Uses statements in the conclusion that are conceptually correct.

3 Substantial Response

Recognizes that the problem involves a significance test on the difference between two proportions, but makes a major error such as:

- fails to address the necessary assumptions
- draws incorrect inference
- does not draw a conclusion or fails to give the conclusion in context

OR

makes two or three less significant errors, such as:

1. Hypotheses errors
2. Notation errors such as not identifying p_1 & p_2 in some manner, not defining non-standard notation, using the same notation for parameters and statistics, etc.
3. Gives z = 1.08, but does not identify the test statistic either by name or by formula.
4. Uses a p-value, critical value, confidence interval, etc., that is inconsistent with α, H_a, etc. (includes failing to adjust p-value for chi-square).
5. Uses two confidence intervals and looks for overlap.
6. Uses language such as "accept H_0," "reject H_a," "the probability that H_0 is true is .14," etc. in the conclusion statement.

2 Developing Response

Performs a statistical inference on the two sample proportions but makes two major errors or an equivalent combination of errors.

1 Minimal Response

Gives a statistical inferential argument that incorporates some measure of error or some notion of chance.

Does little more than carry out the mechanics of the test; e.g., uses the calculator to obtain the test statistic.

Possible Complete Response:

$$H_0: p_1 = p_2 \qquad H_a: p_1 > p_2$$

where p_1 denotes the proportion of voters favoring the new candidate before the incident and p_2 denotes the proportion of voters favoring the new candidate after the incident.

$$\hat{p}_1 = \frac{223}{415} = .537 \qquad \hat{p}_2 = \frac{317}{630} = .503$$

Both samples are large enough that the normal distribution approximation is appropriate.

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}(1-\hat{p})(\frac{1}{n_1}+\frac{1}{n_2})}} = \frac{.537 - .503}{\sqrt{.517(1-.517)(\frac{1}{415}+\frac{1}{630})}} = 1.08.$$

z = 1.08, approximately.

p-value = 1 – .8599 = .14

While the proportion of voters in the sample supporting the candidate after the unfortunate remarks were made is less than the proportion of voters supporting the candidate before the remarks were made, the difference is not significant and can reasonably be attributed to chance.

Sample 1

4. A random sample of 415 potential voters was interviewed 3 weeks before the start of a state-wide campaign for governor; 223 of the 415 said they favored the new candidate over the incumbent. However, the new candidate made several unfortunate remarks one week before the election. Subsequently, a new random sample of 630 potential voters showed that 317 voters favored the new candidate.

Do these data support the conclusion that there was a decrease in voter support for the new candidate after the unfortunate remarks were made? Give appropriate statistical evidence to support your answer.

The null hypothesis is that the proportion of voters who supported the new candidate before the campaign, $\hat{p}_1$, equals the proportion of voters who supported the new candidate a week before the election, $\hat{p}_2$. The alternative hypothesis is that the proportion of voters who supported the new candidate before the campaign, $\hat{p}_1$, is greater than the proportion of voters who supported the new candidate a week before the election. Since I have two sample proportions, each observation within each sample are independent, and $n_1\hat{p}_1$, $n_1(1-\hat{p}_1)$, $n_2\hat{p}_2$, and $n_2(1-\hat{p}_2)$ are all greater than or equal to five, I will use a two-proportion z-test. I found the ~~standard~~ error of the proportion to be $S_{xp} = \sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}$ $= .0315573$8 since the samples are large and they have unequal variances. I computed the critical z-value to be $\frac{\hat{p}_1-\hat{p}_2}{S_{xp}}$ which equaled 1.0817.

The probability that z is greater than 1.0817 is .1396. There is not enough significant evidence to reject the null hypothesis at the 5% level. The new candidate's unfortunate remarks did not significantly affect his support from voters.

Commentary:

The student writes out in great detail exactly what the reasoning process is. The reasoning is very clear and easy to follow. It covers the nature of the problem, the assumptions, the mechanics of the test, and the conclusion, which is stated in the context of the problem. *Score = 4*

Sample 2

4. A random sample of 415 potential voters was interviewed 3 weeks before the start of a state-wide campaign for governor; 223 of the 415 said they favored the new candidate over the incumbent. However, the new candidate made several unfortunate remarks one week before the election. Subsequently, a new random sample of 630 potential voters showed that 317 voters favored the new candidate. $n_1 = 415$ $x_1 = 223$ $n_2 = 630$ $x_2 = 317$

Do these data support the conclusion that there was a decrease in voter support for the new candidate after the unfortunate remarks were made? Give appropriate statistical evidence to support your answer.

$H_0: p_1 = p_2$

$H_a: p_1 > p_2$

$p_1 \rightarrow$ proportion of voter support 3 weeks before election

$p_2 \rightarrow$ proportion of voter support 1 week before election

2 proportion Z test:

$z = 1.082$

p-val = .1397

$x_1 = 223$, $n_1 = 415$, $\hat{p}_1 = .5373$ } 3 weeks before election

Conclusion: do not reject Ho because p-val = .1397 is not statistically significant at $\alpha = .10$; while there is some evidence against Ho, there is not enough evidence to conclude that there was a decrease in voter support for the new candidate after the unfortunate remarks were made

$x_2 = 317$, $n_2 = 630$, $\hat{p}_2 = .5032$ } 1 week before election

$\hat{p}_{pooled} = .5167$

test to see that it's safe to use 2-prop z test:

$n_1p_1 > 5 \rightarrow 415(.5373) = 222.98 > 5$

$n_1(1-p_1) > 5 \rightarrow 415(.4627) = 192.02 > 5$

$n_2p_2 > 5 \rightarrow 630(.5032) = 317.02 > 5$

$n_2(1-p_2) > 5 \rightarrow 295.97 > 5$

most likely that state has > 10 x sample size

Commentary:

The response clearly covers the type of test being done, the assumptions (with a small error in notation), the test statistic and p-value, and the correct conclusion. The conclusion provides a statement in the context of the problem. *Score = 4*

4. A random sample of 415 potential voters was interviewed 3 weeks before the start of a state-wide campaign for governor; 223 of the 415 said they favored the new candidate over the incumbent. However, the new candidate made several unfortunate remarks one week before the election. Subsequently, a new random sample of 630 potential voters showed that 317 voters favored the new candidate.

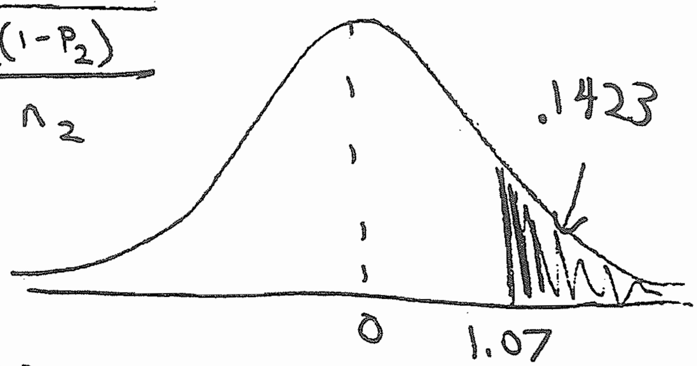
Do these data support the conclusion that there was a decrease in voter support for the new candidate after the unfortunate remarks were made? Give appropriate statistical evidence to support your answer.

H_0: There was no change in voter support after the remarks $p_1 - p_2 = 0$

H_a: There was a decrease in voter support after the remarks $p_1 - p_2 > 0$

$\hat{p}_1 = .537\% = \frac{223}{415}$ $\hat{p}_2 = .503\% = \frac{317}{630}$

$$z^* = \frac{(p_1 - p_2)}{\sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}}$$



$z^* = 1.07$

$p^* = .1423$ $\alpha = .05$

Based on lack of sufficient evidence, fail to reject H_0 that there was no change in voter support after the remarks the new candidate made.

Commentary:

The student carries out the correct test and makes a proper conclusion, but some of the symbols are not defined and no mention is made of assumptions. *Score = 3*

Question 5 Scoring Guidelines

4 Complete Response

A. Selects an appropriate test of significance.

Observes that data are paired by hour of day and indicates a paired t-test is appropriate OR observes that the data are paired by hour of day and justifies choosing a two-sample t-test (or confidence interval for the difference of two proportions) OR worries about assumptions for a t-test and so chooses a sign test OR performs a substantial data analysis.

B. States and addresses assumptions necessary for t-test.

The dot plot below shows no evidence that the differences aren't normally distributed.

```
 .       .  .        .   .   .   .        .                .
+---------+---------+---------+---------+---------+-------d
-5.0     -2.5      0.0       2.5       5.0       7.5
```

(For a two-sample t-test, mentions that outliers indicate a potential problem.)

C. Carries out a test of significance.

States the hypotheses correctly, with two-sided alternative, defining any nonstandard symbols.

$$H_0 : \mu_A = \mu_B \text{ or } \mu_d = 0$$

$$H_a : \mu_A \neq \mu_B \text{ or } \mu_d \neq 0$$

Calculates an appropriate test statistic, possibly with trivial arithmetic error.

$$t = \frac{\bar{d} - 0}{s_d / \sqrt{n}} = \frac{1.11}{4.28 / \sqrt{9}} = 0.78$$

(For two-sample t-test, t = 0.519 and p = 0.61, pooled or unpooled. For a sign test, +-+-++-0+ so P = 0.727.)

Correctly approximates the P-value from a table or calculator.

With 8 degrees of freedom, the two-sided P-value is 0.46 (OR compares t = 0.78 with critical value of 2.306).

OR constructs and interprets a 95% confidence interval for the mean difference:

$$\bar{d} \pm t^* \frac{S_d}{\sqrt{n}} = 1.11 \pm (2.306)\left(\frac{4.28}{\sqrt{9}}\right) = 1.11 \pm 3.29 \text{ or } (-2.18, 4.40)$$

OR a 95% confidence interval for the difference of two means: (-3.47, 5.69)

D. Correctly states a conclusion in the context of the situation.

The difference in the mean percentages in the samples of defective chips produced by ovens A and B isn't statistically significant. If there was no difference in the percentages, a mean absolute difference of 1.11 or greater would happen 46% of the time with random samples of size 9.

Or, for the confidence interval: Since the confidence interval includes zero, there is no evidence that one oven differs from the other in terms of mean percentage of defective chips.

3 Substantial Response

Performs a test of significance but

Doesn't mention the assumptions for the test used

OR

States an incorrect conclusion

OR

Makes two or three less significant omissions or errors in the test of significance, such as

- doesn't make it clear by words or formula which test they are using
- chooses a two-sample t-test or a sign test without considering the paired t-test
- fails to list hypotheses
- does a one-tailed test or forgets to double the P-value
- says must use a t-test because n is small
- uses z-test, not t-test
- mentions normality assumption but doesn't check it graphically or appeal to robustness
- confuses parameters and statistics
- doesn't define nonstandard symbols

- forgets $\frac{1}{\sqrt{n}}$ in formula for t
- uses wrong critical value or degrees of freedom
- "accepts" the null hypothesis or uses similar careless language in conclusion
- gives correct, but minimal, conclusion ("do not reject H_0") or a generic conclusion that doesn't relate to the ovens

2 Developing Response

Performs test of significance except makes both major errors OR an equivalent combination of errors.

1 Minimal Response

Recognizes that the problem involves an inferential statistical argument.

Does little more than carry out the mechanics of a test of significance, such as those done by a calculator.

Note: Since we are using holistic grading, a deficiency in one part can be compensated for by outstanding work in another.

Sample 1

5. A company bakes computer chips in two ovens, oven A and oven B. The chips are randomly assigned to an oven and hundreds of chips are baked each hour. The percentage of defective chips coming from these ovens for each hour of production throughout a day is shown below.

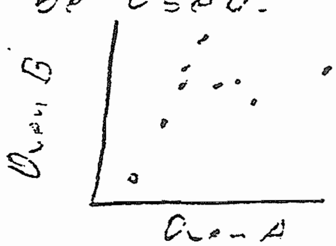
Percentage of Defective Chips

Hour	Oven A	Oven B
1	45	36
2	32	37
3	34	33
4	31	34
5	35	33
6	37	32
7	31	33
8	30	30
9	27	24

The percentage of defective chips produced each hour by oven A has a mean of 33.56 and a standard deviation of 5.20. The percentage of defective chips produced each hour by oven B has a mean of 32.44 and a standard deviation of 3.78. The hourly differences in percentages for oven A minus oven B have a mean of 1.11 and a standard deviation of 4.28.

Does there appear to be a difference between oven A and oven B with respect to the mean percentages of defective chips produced? Give appropriate statistical evidence to support your answer.

To test for a difference between oven A and oven B defective chips, a matched pairs design will be used. The reason is a scatter plot



shows a good positive association between the percentage of defective chips. The probability of obtaing such a high linearity is below .05 according to a linear regression test. If dependence exists, a two sample t-test cannot be done. Thus, the null hypothesis is that the mean of the paired differences of the percent defective chips is 0. The alternative hypothesis is that the mean difference is not equal to 0. A standard alpha of .05 will be used.

The general equation is a one sample t test upon the difference or $t = \frac{\mu_D - 0}{s/\sqrt{n}}$

The degrees of freedom is 9-1 or 8.

Substituting $t = \frac{1.11 - 0}{4.28/\sqrt{9}}$ or $t = .7780$

The probability of of obtaining such a tstatistic or $\geq$ $P(t \geq .7780)$ give 8 degrees of freedom is .4588. This probability value is greater than alpha. The null hypothesis, no difference exists between Oven A and Oven B for the proportion of defective chips. must be accepted.

Commentary:

The response provides a detailed explanation of why the data are regarded as paired (although the regression part is not essential) and even plots the data. The paired t-test is carried out and a correct conclusion is stated in terms of a comparison between the two ovens. (It would be good to plot the differences to show that there are no outliers.) *Score = 4*

Sample 2

5. A company bakes computer chips in two ovens, oven A and oven B. The chips are randomly assigned to an oven and hundreds of chips are baked each hour. The percentage of defective chips coming from these ovens for each hour of production throughout a day is shown below.

Percentage of Defective Chips

Hour	Oven A	Oven B
1	45	36
2	32	37
3	34	33
4	31	34
5	35	33
6	37	32
7	31	33
8	30	30
9	27	24

The percentage of defective chips produced each hour by oven A has a mean of 33.56 and a standard deviation of 5.20. The percentage of defective chips produced each hour by oven B has a mean of 32.44 and a standard deviation of 3.78. The hourly differences in percentages for oven A minus oven B have a mean of 1.11 and a standard deviation of 4.28.

Does there appear to be a difference between oven A and oven B with respect to the mean percentages of defective chips produced? Give appropriate statistical evidence to support your answer.

The data is given to us in matched pairs form, matched by hour. To analyze matched pairs data. I will use a one-sample t-test on the differences. I do this to account for the non-independence that matched pairs has.

$H_0\ \mu_{diff} = 0 \qquad H_a\ \mu_{diff} \neq 0$

$\bar{x}_{diff} = 1.11$

$s = 4.28 \qquad t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} = \frac{1.11 - 0}{4.28/\sqrt{9}} = .778$

$n = 9$

$\alpha = .05$

$df = 8$

critcal $t_{\alpha=.05\ df=8} = 2.306$

$2.306 > 1.778$

Because the critical t is less than the t statistic, I cannot reject H_0 in favor of H_a. I have no evidence to suggest a difference in the percentage of bad chips leaving the oven.

Commentary:

The student correctly recognizes this as a matched pairs problem and analyzes the data accordingly. The conclusion is correctly stated in context. Although assumptions are not mentioned, the student did look at the differences, as indicated by the numbers added to the chart. *Score = 4*

5. A company bakes computer chips in two ovens, oven A and oven B. The chips are randomly assigned to an oven and hundreds of chips are baked each hour. The percentage of defective chips coming from these ovens for each hour of production throughout a day is shown below.

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Does there appear to be a difference between oven A and oven B with respect to the mean percentages of defective chips produced? Give appropriate statistical evidence to support your answer.

See student response on facing page.

$H_0: \mu_A = \mu_B$ μ_A = percentage of defective chips for oven A

$H_a: \mu_A \neq \mu_B$ μ_B = percentage of defective chips for oven B

$$t = \frac{33.56 - 32.44}{\sqrt{\frac{5.20^2}{9} + \frac{3.78^2}{9}}} = .5226548$$

df = 14.6092 ← calculated from TI-82

p = .609015 (from TI-82 with df = 14.6092) or .61538 (with df = 8)

there is not enough evidence to reject Ho in favor of Ha there for there is no difference between the percentage of defective chips between ovens A and B

*note data for oven A is skewed right and since sample size is less than 15 it may effect the t-procedures. We should use a larger sample size.

Commentary:

Here, the data are analyzed by a two-sample t-test on the difference between two means. Given the assumption of two independent samples, the analysis and conclusion are correct. The student correctly notes that there is some skewness in the data. *Score = 3*

Question 6 (Investigative Task) Scoring Guidelines

4 Complete Response

I. Correctly estimates the asking price in dollars for at least two of the three models, including back transforming the predicted value for at least one of models b or c.

a. Price = -58.1 + 0.719(88) = 5.172
asking price is $5,172

b. Ln(price) = -14.9 + 0.185(88) = 1.380
exp(1.38) = 3.9749
asking price = $3,975

c. Sqrt(price) = -13.3 + 0.176(88) = 2.188
$(2.188)^2 = 4.7873$
asking price = $4,787

II. Describes the major shortcoming to be the non-linear pattern in the scatterplot or residual plot for all three models.

III. Suggests a new model that successfully deals with the non-linearity of the data. The prime contenders for this model are:

Fit a simple linear model after the first two or three years are dropped.
(R^2 = .978 with little pattern in the residuals after dropping 79, 82 and 84.)

Fit separate linear models to the earlier and later years.
(R^2 = .985 for the years 86 to 93, with little pattern in the residuals.)

Fit a model that attempts to model the curvature in the data. For example, fit a quadratic model to all of the data.
(R^2 = .974 with little pattern in the residuals for a quadratic model.)

IV. Justifies why this model is better. For example, comments that there is no pattern in the residuals as seen from looking at the fitted model on the scatterplot or from looking at the residual plot.

3 Substantial Response

Fails to do one of the following satisfactorily:

- Part I (for example, by failing to back transform the prediction)
- describe the major shortcomings of the three models
- justify why the new model is better (for example, by failing to comment on the residual plot)

2 Developing Response

Fails to do one of the following satisfactorily:

- Part I and describe the major shortcomings of the three models
- Part I and justify why the new model is better
- suggest a new model and justify it
- describe the major shortcomings of the three models and justify why the new model is better.

1 Minimal Response

Gives correct responses to one of the items I, II, or III above. **Note:** Students cannot get IV correct without first specifying a new model.

Sample 1

(a) Use Model 1 to establish an asking price for your 1988 automobile.

$$\text{Price} = -58.1 + 0.719(88) \approx \boxed{\$5,170}$$

(b) Use Model 2 to establish an asking price for your 1988 automobile.

$$\ln \text{Price} = -14.9 + 0.185(88) = 1.38$$

$$\text{Price} = e^{1.38} \approx \boxed{\$3,970}$$

(c) Use Model 3 to establish an asking price for your 1988 automobile.

$$\sqrt{\text{Price}} = -13.3 + 0.176(88) = 2.188$$

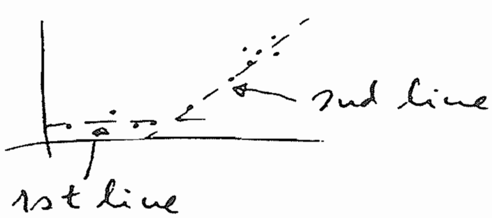
$$\text{Price} = 2.188^2 \approx \boxed{\$4,790}$$

(d) Describe any shortcomings you see in these three models.

Although the correlation coefficients are all quite large, the residual plots all show a distinct pattern, which means that neither fit is the correct one for the data

(e) Use some or all of the given data to find a better method for establishing an asking price for your 1988 automobile. Explain why your method is better.

From the plot of Model 1 it is clear that a better fit for the data would be two lines instead of one. The first one would be the least-squares regression line on the years prior to 1986 and would be valid only for these years, while the other one would be the regression line on the years of 1986 and later, and would be valid for those years. In this case, any pattern in the residual plot would disappear, and the asking price of the 1988 automobile could be determined from the second line of the fit.



Commentary:

Parts (a), (b), and (c) show correct calculations and (d) contains a comment on the pattern in the residual plots. Part (e) contains a clear description of how the data could be split into two groups, each showing a linear trend but with different slopes. *Score = 4*

Sample 2

(a) Use Model 1 to establish an asking price for your 1988 automobile.

$$\text{price} = -58.1 + .719(\text{year})$$
$$= -58.1 + .719 \cdot 88$$
$$= 5.172 \text{ (thousand dollars)}$$
$$\therefore \text{ price} = \boxed{\$5172}$$

(b) Use Model 2 to establish an asking price for your 1988 automobile.

$$\ln \text{price} = -14.9 + .185 \cdot \text{year}$$
$$= -14.9 + .185 \cdot 88$$
$$\ln p = 1.38$$
$$p = e^{1.38} = 3.975 \text{ (thousand \$)}$$
$$\therefore \text{ price} = \boxed{\$3975}$$

(c) Use Model 3 to establish an asking price for your 1988 automobile.

$$\sqrt{\text{price}} = -13.3 + .176 \cdot \text{year}$$
$$= -13.3 + .176 \cdot 88$$
$$= 2.188$$
$$\text{price} = 2.188^2 = 4.787 \text{ (thousand \$)}$$
$$\therefore \text{ price} = \boxed{\$4787}$$

(d) Describe any shortcomings you see in these three models.

The residuals, which should be random in the best regression, exhibit curved patterns on all three graphs. Also, r^2, which should be at least .97 or .98, is .946 or lower on every graph.

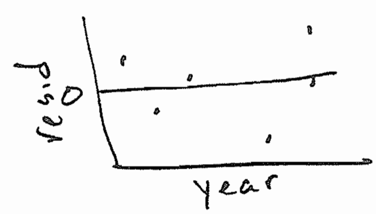
(ln price vs. ln year does not correct this. I tried.)

(e) Use some or all of the given data to find a better method for establishing an asking price for your 1988 automobile. Explain why your method is better.

Eliminate from our data pool all cars more than three years away from our 1988 car: before 1985 or after 1991. Then, we get a data set with the following graph (sketched from calculator):

and a least squares regression of [price = $-92 + 1.096$(year)].

The plot of the residuals is



which is fairly random.

Subtituting in our year, we get a price of

price $= -92 + 1.096(88) = 4.448$ = \$4448

which seems to correspond to nearby years fairly well.

Commentary:

The numerical calculations in the first three parts are correct. The pattern in the residuals is recognized. The solution to improve the fit is to concentrate on the years around 1988, and this is a reasonable way to improve the fit. *Score = 4*

Sample 3

(a) Use Model 1 to establish an asking price for your 1988 automobile.

$f(88) = \underline{5.172 \text{ thousand dollars}}$

$-58.1 + 0.719 \cdot 88$

(b) Use Model 2 to establish an asking price for your 1988 automobile.

$f(88) = 1.38$ $e^{1.38} = \underline{3.9749 \text{ thousand dollars}}$

$-14.9 + 0.185 \cdot 88 =$

(c) Use Model 3 to establish an asking price for your 1988 automobile.

$-13.3 + 0.176 \cdot 88 = 2.188$ $2.188^2 = \underline{4.7873 \text{ thousand dollars}}$

(d) Describe any shortcomings you see in these three models.

These models include all of the data. According to the regression equation for the first model, a 1980 car would sell for −0.58 thousand dollars. We know that cars will sell for a minimum amount of money. You can sell almost any car for about a thousand dollars. You should therefor not include data from cars older than a certain year.

(e) Use some or all of the given data to find a better method for establishing an asking price for your 1988 automobile. Explain why your method is better.

It appears that the regression equation for this data would fit better if the data from years 1979 and 1982 were omitted. If we were to find out prices for cars older than 1984 we would probably find that most of them sold for around 1 thousand dollars. By omitting '79 and '82, our new regression equation for model 1 is $-81.1342 + 0.9747 \cdot \text{year}$. $r^2 = 97.12\%$ This is a much better fit than the previous equation. Our new asking price would be 4.64 thousand dollars which would be closer to the true market value.

Commentary:

The calculations in (a), (b), and (c) are correct. In part (e), a good solution is suggested in terms of eliminating the early years from the analysis. The main weakness of the response is that the pattern in the residuals is not recognized in (d). *Score = 3*

Chapter IV Statistical Information

- Table 4.1 — Section II Scores
- How AP Grades are Determined
- Table 4.3 — Grade Distributions
- Table 4.4 — Section I Scores and AP Grades
- College Comparability Studies
- Reminders for all Grade Report Recipients
- Reporting AP Grades
- Purpose of AP Grades

Table 4.1 — Section II Scores

These are the score distributions for the total group of candidates on each free-response question from the 1997 exam.

	Question 1		Question 2		Question 3	
Score	Number of Students	% At Score	Number of Students	% At Score	Number of Students	% At Score
4	544	7.1	134	1.8	948	12.4
3	1261	16.5	1234	16.1	179	2.3
2	1232	16.1	4675	61.1	1410	18.5
1	1612	21.1	885	11.6	969	12.7
0	2797	36.6	530	6.9	3551	46.4
*NR	200	2.6	188	2.5	589	7.7

	Question 4		Question 5		Question 6**	
Score	Number of Students	% At Score	Number of Students	% At Score	Number of Students	% At Score
8					170	2.2
7					157	2.1
6					241	3.1
5					292	3.8
4	159	2.1	19	0.2	580	7.6
3	2629	34.4	1285	16.9	594	7.8
2	1419	18.5	2525	33.0	1841	24.1
1	1128	14.8	1626	21.2	734	9.6
0	2163	28.3	1848	24.2	2570	33.6
*NR	148	1.9	343	4.5	467	6.1

*NR — No response. Student gave either no response or a response not on the topic.

**Question 6 was read by two different faculty consultants, and the two scores were combined.

	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6
Total Candidates	7,646	7,646	7,646	7,646	7,646	7,646
Mean	1.31	1.89	1.06	1.63	1.39	1.82
Standard Deviation	1.32	0.84	1.39	1.28	1.08	2.05
Mean as % of Maximum Score	33	47	27	41	35	23

How AP Grades are Determined

AP Statistics students can receive 0 to 50 points in each section of the exam. However, these scores are not released to the student, school, or college. Instead, these raw scores are converted to grades on an AP 5-point scale, and it is these grades that are reported. This conversion involves a number of steps:

1. **The multiple-choice score is calculated.** To adjust for random guessing, a fraction of the number of wrong answers is subtracted from the number of right answers. This fraction is 1/4 for five-choice questions (as on the Statistics exam), so that the expected score from random guessing will be zero.
2. **The free-response score is calculated.** When the free-response section includes two or more parts, those parts are weighted according to the value assigned to them by the Development Committee. This allows the Development Committee to place more importance on certain skills to correspond to their emphasis in the corresponding college curriculum.
3. **A composite score is calculated.** Weighting also comes into play when looking at the multiple-choice section in comparison to the free-response section. In consultation with experts from the College Board and ETS, the Statistics committee decided that each section should contribute an equal amount to the total score. The maximum composite score was 100, with each section contributing up to 50 points. The Scoring Worksheet on the facing page details the process of converting section scores to composite scores for this examination.
4. **AP grades are calculated.** The Chief Faculty Consultant sets the four cut points that divide the composite scores into groups. A variety of information is available to help the CFC determine the score ranges into which the exam grades should fall:
   - Distributions of scores on each portion of the multiple-choice and free-response sections of the exam are provided, along with totals for each section and the composite score total.
   - With these tables and special statistical tables presenting grade distributions from previous years, the CFC can compare the exam at hand to results of other years.
   - For each composite score, a table summarizes student performance on all sections of the exam.
   - Finally, on the basis of professional judgment regarding the quality of performance represented by the achieved scores, the CFC determines the candidates' final AP grades.

   See Table 4.3 for the 1997 AP Statistics Exam grade distributions.

If you're interested in more detailed information about this process, please see the "Technical Corner" of our website: www.collegeboard.org/ap. There you'll also find information about how the AP exams are developed, how validity and reliability studies are conducted, and other nuts-and-bolts data on all AP subjects.

Table 4.2 — Scoring Worksheet

Section I: Multiple Choice

[________ − (1/4 × ________)] × 1.4286 = ________ = ________

Number correct (out of 35) | Number wrong | Multiple-Choice Score (Round to nearest whole number. If less than zero, enter zero.) | Weighted Section I Score

Section II: Free Response

Question 1 ________ (out of 4) × 1.875 = ________ (Do not round)

Question 2 ________ (out of 4) × 1.875 = ________ (Do not round)

Question 3 ________ (out of 4) × 1.875 = ________ (Do not round)

Question 4 ________ (out of 4) × 1.875 = ________ (Do not round)

Question 5 ________ (out of 4) × 1.875 = ________ (Do not round)

Question 6 ________ (out of 8) × 1.5625 = ________ (Do not round)

Sum = ________

Weighted Section II Score (Do not round.)

Composite Score

________ + ________ = ________

Weighted Section I Score | Weighted Section II Score | Composite Score (Round to the nearest whole number.)

AP Grade Conversion Chart

Composite Score Range*	AP Grade
68-100	5
54-67	4
41-53	3
29-40	2
0-28	1

*The candidates' scores are weighted according to formulas determined in advance each year by the Development Committee to yield raw composite scores; the Chief Faculty Consultant is responsible for converting composite scores to the 5-point AP scale.

Table 4.3 — Grade Distributions

More than 62% of the candidates earned an AP grade of 3 or higher.

	Examination Grade	Total Group Number of Students	Percent at Grade
Extremely well qualified	5	1,193	15.6
Well qualified	4	1,692	22.1
Qualified	3	1,872	24.5
Possibly qualified	2	1,502	19.6
No recommendation	1	1,387	18.1
Total Number of Students		7,646	
Mean Grade		2.97	
Standard Deviation		1.33	

Table 4.4 — Section I Scores and AP Grades

This table gives the probabilities that a student would receive a particular grade on the 1997 AP Statistics Exam given that student's score on the multiple-choice section.

Multiple-Choice Score	AP Grade					Total
	1	2	3	4	5	
30 to 35	0.0%	0.0%	0.6%	19.6%	79.8%	13.7%
25 to 29	0.0%	0.4%	19.4%	60.8%	19.3%	23.7%
21 to 24	0.0%	12.2%	64.3%	23.1%	0.3%	20.1%
15 to 20	10.2%	60.3%	28.1%	1.5%	0.0%	24.1%
0 to 14	85.4%	14.0%	0.6%	0.0%	0.0%	18.4%
Total	18.1%	19.6%	24.5%	22.1%	15.6%	100.0%

College Comparability Studies

Because the 1997 exam was the first one developed for statistics, a comparability study was done. In this study, college students enrolled in introductory statistics courses equivalent to the AP Statistics course were given a mini-version of the exam. These mini-versions contained a subset of the questions in the exam. The scores obtained by the college students and the grades they received in their course were used to help determine the appropriate AP grade for the AP students taking the examination.

The AP Program has conducted college grade comparability studies in all other AP subjects as well. As with Statistics, these studies compared the performance of AP Exam candidates with that of college students in related courses who have taken the AP Exam at the end of their course. In general, AP cutpoints are selected so that the lowest AP 5 is equivalent to the average A student in college, the lowest AP 4 equivalent to the average B student, and the lowest AP 3 equivalent to the average C student (see figure below).

AP Grade	Average College Grade
5	
	A
4	
	B
3	
	C
2	
	D
1	

To ensure comparability of grades from year to year and to maintain a certain level of difficulty, some multiple-choice questions from previous AP Statistics exams will be included on each new examination.

Reminders for All Grade Report Recipients

AP Examinations are designed to provide accurate assessments of achievement. However, any examination has limitations, especially when used for purposes other than those intended. Presented here are some suggestions for teachers to aid in the use and interpretation of AP grades.

- AP Examinations are developed and evaluated independently of each other. They are linked only by common purpose, format, and method of reporting results. Therefore, comparisons should not be made between grades on different AP Examinations. An AP grade in one subject may not have the same meaning as the same AP grade in another subject, just as national and college standards vary from one discipline to another.
- AP grades are not exactly comparable to college course grades. However, the AP Program conducts research studies every few years in each AP subject to ensure that the AP grading standards are comparable to those used in colleges with similar courses.
- The confidentiality of candidate grade reports should be recognized and maintained. All individuals who have access to AP grades should be aware of the confidential nature of the grades and agree to maintain their security. In addition, school districts and states should not release data about high school performance without the school's permission.
- AP Examinations are not designed as instruments for teacher or school evaluation. A large number of factors influence AP Exam performance in a particular course or school in any given year. As a result, differences in AP Exam performance should be carefully studied before being attributed to the teacher or school.
- Where evaluation of AP students, teachers, or courses is desired, local evaluation models should be developed. An important aspect of any evaluation model is the use of an appropriate method of comparison or frame of reference to account for yearly changes in student composition and ability, as well as local differences in resources, educational methods, and socioeconomic factors.

- The "Report to AP Teachers" can be a useful diagnostic tool in reviewing course results. This report identifies areas of strength and weakness for each AP course. This information may also help to guide your students in identifying their own strengths and weaknesses in preparation for future study. (See below for information on how to obtain this report.)
- Many factors can influence course results. AP Exam performance may be due to the degree of agreement between your course and the course defined in the relevant AP Course Description, use of different instructional methods, differences in emphasis or preparation on particular parts of the examination, differences in pre-AP curriculum, or differences in student background and preparation in comparison with the national group.

Reporting AP Grades

The results of AP Examinations are disseminated in several ways to candidates, their secondary schools, and the colleges they select.

- College and candidate grade reports contain a cumulative record of all grades earned by the candidate on AP Exams during the current or previous years. These reports are sent in early July. (School grade reports are sent shortly thereafter.)
- Group results for AP Examinations are available to AP teachers whenever five or more candidates at a school have taken a particular AP Exam. This "Report to AP Teachers" provides useful information comparing local candidate performance with that of the total group of candidates taking an exam, as well as details on different subsections of the exam.

Several other reports produced by the AP Program provide summary information on AP Examinations.

- State and National Reports show the distribution of grades obtained on each AP Exam for all candidates and for subsets of candidates broken down by sex and by ethnic group.
- The Program also produces a one-page summary of AP grade distributions for all exams in a given year.

For information on any of the above, please call AP Services at (609) 771-7300 or contact them via e-mail at apexams@ets.org.

Purpose of AP Grades

AP grades are intended to allow participating colleges and universities to award college credit, advanced placement, or both to qualified students. In general, an AP grade of 3 or higher indicates sufficient mastery of course content to allow placement in the succeeding college course, or credit for and exemption from a college course comparable to the AP course. Credit and placement policies are determined by each college or university, however, and students should be urged to contact their colleges directly to ask for specific Advanced Placement policies in writing.

Appendix AP Publications and Videos

A number of AP publications and videos are available to help students, parents, AP Coordinators, and high school and college faculty learn more about the AP Program and its courses and exams. To sort out those publications that may be of particular use to you, refer to the following key:

Students and Parents	SP
Teachers	T
AP Coordinators and Administrators	A
College Faculty	C

You can order many items online through the AP Aisle of the College Board Online store at http://cbweb2.collegeboard.org/shopping/. Alternatively, call AP Order Services at (609) 771-7243. American Express, VISA, and MasterCard are accepted for payment.

If you are mailing your order, send it to the Advanced Placement Program, Dept. E-05, P.O. Box 6670, Princeton, NJ 08541-6670. Payment must accompany all orders not on an institutional purchase order or credit card, and checks should be made payable to the College Board.

The College Board pays fourth-class book rate postage (or its equivalent) on all prepaid orders; you should allow between four and six weeks for delivery. Postage will be charged on all orders requiring billing and/or requesting a faster method of shipment.

Publications may be returned within 30 days of receipt if postage is prepaid and publications are in resalable condition and still in print. Unless otherwise specified, orders will be filled with the currently available edition; prices are subject to change without notice.

AP Bulletin for Students and Parents: Free **SP**

This bulletin provides a general description of the AP Program, including policies and procedures for preparing to take the exams, and registering for the AP courses. It describes each AP Exam, lists the advantages of taking the exams, describes the grade and award options available to students, and includes the upcoming exam schedule.

College and University Guide to the AP Program: $10 **C, A**

This guide is intended to help college and university faculty and administrators understand the benefits of having a coherent, equitable AP policy. Topics included are validity of AP grades; developing and maintaining scoring standards; ensuring equivalent achievement; state legislation supporting AP; and quantitative profiles of AP students by each AP subject.

The College Handbook with College Explorer® CD-ROM: $25.95 **SP, T, A, C**

Includes brief outlines of AP placement and credit policies at two- and four-year colleges across the country. Notes number of freshmen granted placement and/or credit for AP in the prior year.

Course Descriptions: $12 **SP, T, A, C**

Course Descriptions provide an outline of the AP course content, explain the kinds of skills students are expected to demonstrate in the corresponding introductory college-level course, and describe the AP Exam. They also provide sample multiple-choice questions with an answer key, as well as sample free-response questions. A set of Course Descriptions is available for $100. Not included in this set are Course Descriptions for Computer Science, Government and Politics, and Statistics, which are available for downloading from the AP section of the College Board website (free of charge).

Five-Year Set of Free-Response Questions: $5 **T**

This is our no-frills publication. Each booklet contains copies of all the free-response questions from the last five exams in its subject; nothing more, nothing less. Collectively, the questions represent a comprehensive sampling of the concepts assessed on the exam in recent years and will give teachers plenty of materials to use for essay-writing or problem-solving practice during the year. (If there have been any content changes to the exam in the past five years, it will be noted on the cover of the booklet.)

Grading, Interpreting, and Using Advanced Placement Examinations: Free A, C, T

A booklet containing information on the development of scoring standards, the AP Reading, grade-setting procedures, and suggestions on how to interpret AP grades.

Guide to the Advanced Placement Program: Free A

Written for both administrators and AP Coordinators, this guide is divided into two sections. The first section provides general information about AP, such as how to organize an AP program at your high school, the kind of training and support that is available for AP teachers, and a look at the AP Exams and grades. The second section contains more specific details about testing procedures and policies and is intended for AP Coordinators.

Released Exams: $20 T

About every four years, on a staggered schedule, the AP Program releases a complete copy (multiple-choice and free-response sections) of each exam, as in the case of the 1997 Statistics Exam.

Packets of 10 ($30): For each subject with a released exam, you can purchase a packet of 10 copies of that year's exams for use in your classroom (e.g., to simulate an AP exam administration).

Secondary School Guide to the AP Program: $10 A, T

This guide is a comprehensive consideration of the AP Program. It covers topics such as: developing or expanding an AP program; gaining faculty, administration, and community support; AP grade reports, their use and interpretation; AP Scholar Awards; receiving college credit for AP; AP teacher training resources; descriptions of successful AP programs in nine schools around the country; and "Voices of Experience," a collection of ideas and tips from AP teachers and administrators.

Videoconference Tapes: $15 T, C

AP conducts live, interactive videoconferences for various subjects, enabling AP teachers and students to talk directly with the Development Committees that design the AP Exams. Tapes of these events are available in VHS format and are approximately 90 minutes long.

Teacher's Guides: $12 T

Whether you're about to teach an AP course for the first time, or you've done it for years but would like to get some fresh ideas for your classroom, the Teacher's Guide can be your mentor. It contains syllabi developed by high school teachers currently teaching the AP course and college faculty who teach the equivalent course at their institution. Along with detailed course outlines and innovative teaching tips, you'll also find extensive lists of recommended teaching resources.

AP Pathway to Success (video, available in English and Spanish): $15 SP, T, A, C

This 25-minute-long video takes a look at the AP Program through the eyes of people who know AP: students, parents, teachers, and college admissions staff. They answer such questions as "Why Do It?", "Who Teaches AP Courses?", and "Is AP For You?". College students discuss the advantages they gained through taking AP, such as academic self-confidence, writing skills, and course credit. AP teachers explain what the challenge of teaching AP courses means to them and their school, and admissions staff explain how they view students who have stretched themselves by taking AP Exams. There is also a discussion of the impact that an AP program has on an entire school and its community, and a look at resources available to help AP teachers, such as regional workshops, teacher conferences, and summer institutes.

What's in a Grade? (video): $15 T, C

AP Exams are composed of multiple-choice questions (scored by computer), and free-response questions that are scored by qualified professors and teachers. This video presents a behind-the-scenes look at the scoring process featuring footage shot on location at the 1992 AP Reading at Clemson University and other Reading sites. Using the AP European History Exam as a basis, the video documents the scoring process. It shows AP faculty consultants in action as they engage in scholarly debate to define precise scoring standards, then train others to recognize and apply those standards. Footage of other subjects, interviews with AP faculty consultants, and explanatory graphics round out the video.

AP® Statistics

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