



# **AP<sup>®</sup> Statistics Practice Exam**

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**From the 2012 Administration**

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- Teachers are permitted to download the materials and make copies to use with the students in a classroom setting only.

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**Note:** This publication shows the page numbers that appeared in the *2011–12 AP Exam Instructions* book and in the actual exam. This publication was not repaginated to begin with page 1.

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## **Exam Instructions**

The following contains instructions taken from the *2011–12 AP Exam Instructions* book.

# AP<sup>®</sup> Statistics Exam

Regularly Scheduled Exam Date: Wednesday afternoon, May 16, 2012

Late-Testing Exam Date: Wednesday morning, May 23, 2012

## Section I: At a Glance

**Total Time:**

1 hour, 30 minutes

**Number of Questions:**

40

**Percent of Total Score:**

50%

**Writing Instrument:**

Pencil required

**Electronic Device:**

Graphing calculator  
expected

## Section II: At a Glance

**Total Time:**

1 hour, 30 minutes

**Number of Questions:**

6

**Percent of Total Score:**

50%

**Writing Instrument:**

Either pencil or pen with black  
or dark blue ink

**Electronic Device:**

Graphing calculator  
expected

**Part A:****Number of Questions:**

5

**Suggested Time:**

1 hour, 5 minutes

**Percent of Section II Score:**

75%

**Part B:****Number of Questions:**

1

**Suggested Time:**

25 minutes

**Percent of Section II Score:**

25%

## Section I: Multiple Choice Booklet Instructions

Section I of this exam contains 40 multiple-choice questions. Fill in only the circles for numbers 1 through 40 on your answer sheet.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work. After you have decided which of the suggested answers is best, completely fill in the corresponding circle 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.

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on the multiple-choice section is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

## Section II: Free Response Booklet Instructions

The questions for both Part A and Part B are printed in this booklet. You may use any blank space in the booklet to organize your answers and for scratch work, but you must write your answers in the spaces provided for each answer. Pages containing statistical tables and useful formulas are printed in this booklet.

You may wish to look over the questions before starting to work on them. It is not expected that everyone will be able to complete all parts of all questions. Show all your work. Indicate clearly the methods you use because you will be scored on the correctness of your methods as well as the accuracy and completeness of your results and explanations. Correct answers without supporting work may not receive credit. Write your solution to each part of each question in the space provided for that part. Write clearly and legibly. Cross out any errors you make; erased or crossed-out work will not be scored.

Manage your time carefully. The proctor will announce the suggested time for Part A and Part B, but you may proceed freely from one question to the next. You may review your responses if you finish before the end of the exam is announced.

### What Proctors Need to Bring to This Exam

- Exam packets
- Answer sheets
- AP Student Packs
- *2011-12 AP Coordinator’s Manual*
- This book — *AP Exam Instructions*
- School Code and Home-School/Self-Study Codes
- Extra graphing calculators
- Pencil sharpener
- Extra No. 2 pencils with erasers
- Extra pens with black or dark blue ink
- Extra paper
- Stapler
- Watch
- Signs for the door to the testing room
  - “Exam in Progress”
  - “Cell phones are prohibited in the testing room”

Students are expected to bring graphing calculators to this exam. Before starting the exam, make sure no one has a laptop or other portable/handheld computer, pocket organizer, calculator with a QWERTY keyboard (e.g., TI-92 Plus, Voyage 200), electronic writing pad, or pen-input/stylus-driven device (e.g., Palm Pilot). Cell phone calculators are not allowed. If a student has a calculator that is not acceptable or has one that does not have statistical capabilities, you may provide one from your supply. See pages 40–42 of the *2011-12 AP Coordinator’s Manual*. If the student does not want to use the calculator you provide, he or she must hand copy, date, and sign the release statement on page 41 of the *Manual*.

Students may have no more than two calculators on their desks, and calculators may not be shared. Students with Hewlett-Packard 48 Series graphing calculators may use cards designed for use with these calculators. Proctors should make sure Hewlett-Packard calculators’ infrared ports are not facing each other. Since graphing calculators can be used to store data, including text, proctors should monitor that students are using their calculators appropriately. Attempts by students to use the calculator to remove exam questions and/or answers from the room may result in cancellation of AP Exam scores.

## SECTION I: Multiple Choice

- **Do not begin the exam instructions below until you have completed the appropriate**
- **General Instructions for your group.**

Make sure you begin the exam at the designated time.

*If you are giving the regularly scheduled exam, say:*

**It is Wednesday afternoon, May 16, and you will be taking the AP Statistics Exam.**

*If you are giving the alternate exam for late testing, say:*

**It is Wednesday morning, May 23, and you will be taking the AP Statistics Exam.**

In a moment, you will open the packet that contains your exam materials. By opening this packet, you agree to all of the AP Program’s policies and procedures outlined in the *2011-12 Bulletin for AP Students and Parents*. You may now remove the shrinkwrap from your exam packet and take out the Section I booklet, but do not open the booklet or the shrinkwrapped Section II materials. Put the white seals aside. . . .

Look at page 1 of your answer sheet and locate the dark blue box near the top right-hand corner that states, “Take the AP Exam label from your Section I booklet and place the label here.”. . .

Now look at the front cover of your exam booklet and locate the AP Exam label near the top left of the cover. . . .

Carefully peel off the AP Exam label and place it on your answer sheet on the dark blue box that we just identified. . . .

Now read the statements on the front cover of Section I and look up when you have finished. . . .

Sign your name, and write today’s date. Look up when you have finished. . . .

Now print your full legal name where indicated. Are there any questions? . . .

Turn to the back cover and read it completely. Look up when you have finished. . . .

Are there any questions? . . .

Section I is the multiple-choice portion of the exam. You may never discuss these specific multiple-choice questions at any time in any form with anyone, including your teacher and other students. If you disclose these questions through any means, your AP Exam score will be canceled. Are there any questions? . . .

You must complete the answer sheet using a No. 2 pencil only. Mark all of your responses on your answer sheet, one response per question. Completely fill in the circles. If you need to erase, do so carefully and completely. No credit will be given for anything written in the exam booklet. Scratch paper is not allowed, but you may use the margins or any blank space in the exam booklet for scratch work. Calculators may be used for both sections of this exam. You may place your calculators on your desk. Are there any questions? . . .

You have 1 hour and 30 minutes for this section. Open your Section I booklet and begin.



Note Start Time here \_\_\_\_\_. Note Stop Time here \_\_\_\_\_. Check that students are marking their answers in pencil on their answer sheets, and that they are not looking at their shrinkwrapped Section II booklets. Proctors should walk around and make sure Hewlett-Packard calculators' infrared ports are not facing each other. After 1 hour and 30 minutes, say:

**Stop working. Close your booklet and put your answer sheet on your desk, face up. Make sure you have your AP number label and an AP Exam label on page 1 of your answer sheet. I will now collect your answer sheet.**

Collect an answer sheet from each student. Check that each answer sheet has an AP number label and an AP Exam label. Then say:

**Now you must seal your exam booklet. Remove the white seals from the backing and press one on each area of your exam booklet cover marked "PLACE SEAL HERE." Fold each seal over the back cover. When you have finished, place the booklet on your desk, face up. I will now collect your Section I booklet. . . .**

Check that each student has signed the front cover of the sealed Section I booklet. There is a 10-minute break between Sections I and II. When all Section I materials have been collected and accounted for and you are ready for the break, say:

**Please listen carefully to these instructions before we take a 10-minute break. Everything you placed under your chair at the beginning of the exam must stay there. Leave your shrinkwrapped Section II packet on your desk during the break. You are not allowed to consult teachers, other students, or textbooks about the exam during the break. You may not make phone calls, send text messages, check email, use a social networking site, or access any electronic or communication device. Remember, you are not allowed to discuss the multiple-choice section of this exam. Failure to adhere to any of these rules could result in cancellation of your score. Are there any questions? . . .**



You may begin your break. Testing will resume at \_\_\_\_\_.

## SECTION II: Free Response

After the break, say:

**May I have everyone's attention? Place your Student Pack on your desk. . . .**

**You may now remove the shrinkwrap from the Section II packet, but do not open the exam booklet until you are told to do so. . . .**

**Read the bulleted statements on the front cover of the exam booklet. Look up when you have finished. . . .**

**Now place an AP number label on the shaded box. If you don't have any AP number labels, write your AP number in the box. Look up when you have finished. . . .**

**Read the last statement. . . .**

Using your pen, print the first, middle and last initials of your legal name in the boxes and print today’s date where indicated. This constitutes your signature and your agreement to the statements on the front cover. . . .

Turn to the back cover and read Item 1 under “Important Identification Information.” Print the first two letters of your last name and the first letter of your first name in the boxes. Look up when you have finished. . . .

In Item 2, print your date of birth in the boxes. . . .

In Item 3, write the school code you printed on the front of your Student Pack in the boxes. . . .

Read Item 4. . . .

Are there any questions? . . .

I need to collect the Student Pack from anyone who will be taking another AP Exam. You may keep it only if you are not taking any other AP Exams this year. If you have no other AP Exams to take, place your Student Pack under your chair now. . . .

While Student Packs are being collected, read the information on the back cover of the exam booklet. Do not open the booklet until you are told to do so. Look up when you have finished. . . .

Collect the Student Packs. Then say:

Are there any questions? . . .

Section II has two parts. You have 1 hour and 30 minutes to complete all of Section II. You are responsible for pacing yourself, and may proceed freely from one part to the next. You must write your answers in the exam booklet using a pen or a No. 2 pencil. If you use a pencil, be sure that your writing is dark enough to be easily read. If you need more paper during the exam, raise your hand. At the top of each extra piece of paper you use, be sure to write only your AP number and the number of the question you are working on. Do not write your name. Are there any questions? . . .

You may begin Part A.



Note Start Time here \_\_\_\_\_. Note Stop Time here \_\_\_\_\_. Check that students are writing their answers in their exam booklets. You should also make sure that calculators’ infrared ports are not facing each other and that students are not sharing calculators. After 1 hour and 5 minutes, say:

**There are 25 minutes remaining and you may want to move on to Part B, if you have not already started answering that question.**

After 15 minutes, say:

**There are 10 minutes remaining.**

After 10 minutes, say:

**Stop working and close your exam booklet. Place it on your desk, face up. . . .**



If any students used extra paper for the free-response section, have those students staple the extra sheet/s to the first page corresponding to that question in their exam booklets. Then say:

**Remain in your seat, without talking, while the exam materials are collected. . . .**

Collect a Section II booklet from each student. Check for the following:

- Exam booklet front cover: The student placed an AP number label on the shaded box, and printed his or her initials and today's date.
- Exam booklet back cover: The student completed the "Important Identification Information" area.

When all exam materials have been collected and accounted for, return to students any electronic devices you may have collected before the start of the exam.

*If you are giving the regularly scheduled exam, say:*

**You may not discuss these specific free-response questions with anyone unless they are released on the College Board website in about two days. You should receive your score report in the mail about the third week of July.**

*If you are giving the alternate exam for late testing, say:*

**None of the questions in this exam may ever be discussed or shared in any way at any time. You should receive your score report in the mail about the third week of July.**

If any students completed the AP number card at the beginning of this exam, say:

**Please remember to take your AP number card with you.**

Then say:

**You are now dismissed.**

All exam materials should be put in secure storage until they are returned to the AP Program after your school's last administration. Before storing materials, check the "School Use Only" section on page 1 of the answer sheet and:

- Fill in the appropriate section number circle in order to view a separate AP Instructional Planning Report (for regularly scheduled exams only) or Subject Score Roster at the class section or teacher level. See "Post-Exam Activities" in the *2011-12 AP Coordinator's Manual*.
- Check your list of students who are eligible for fee reductions and fill in the appropriate circle on their registration answer sheets.

**GO ON TO THE NEXT PAGE.**

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## **Student Answer Sheet for the Multiple-Choice Section**

Use this section to capture student responses. (Note that the following answer sheet is a sample, and may differ from one used in an actual exam.)











**GO ON TO THE NEXT PAGE.**



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## **Section I: Multiple-Choice Questions**

This is the multiple-choice section of the 2012 AP exam. It includes cover material and other administrative instructions to help familiarize students with the mechanics of the exam. (Note that future exams may differ in look from the following content.)

PLACE SEAL HERE

# AP<sup>®</sup> Statistics Exam

## SECTION I: Multiple Choice

2012

**DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.**

### At a Glance

**Total Time**  
1 hour, 30 minutes

**Number of Questions**  
40

**Percent of Total Score**  
50%

**Writing Instrument**  
Pencil required

**Electronic Device**  
Graphing calculator expected

### Instructions

Section I of this exam contains 40 multiple-choice questions. Fill in only the circles for numbers 1 through 40 on your answer sheet.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work. After you have decided which of the suggested answers is best, completely fill in the corresponding circle 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. Here is a sample question and answer.

Sample Question      Sample Answer

Chicago is a      (A) ● (C) (D) (E)

(A) state

(B) city

(C) country

(D) continent

(E) village

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on the multiple-choice section is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

PLACE SEAL HERE



Minimum 20% post-consumer waste

PLACE SEAL HERE

DO NOT seal answer sheet inside

Form I  
Form Code 4IBP4-S

90

Formulas begin on page 3.  
Questions begin on page 6.  
Tables begin on page 42.

## Formulas

(I) Descriptive Statistics

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

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

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

$$\hat{y} = b_0 + b_1x$$

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

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

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

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

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

(II) Probability

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

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

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

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

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  $\bar{x}$  is the mean of a random sample of size  $n$  from an infinite population with mean  $\mu$  and standard deviation  $\sigma$ , then:

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

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

(III) Inferential Statistics

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

Confidence interval:  $\text{statistic} \pm (\text{critical value}) \cdot (\text{standard deviation of statistic})$

Single-Sample

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

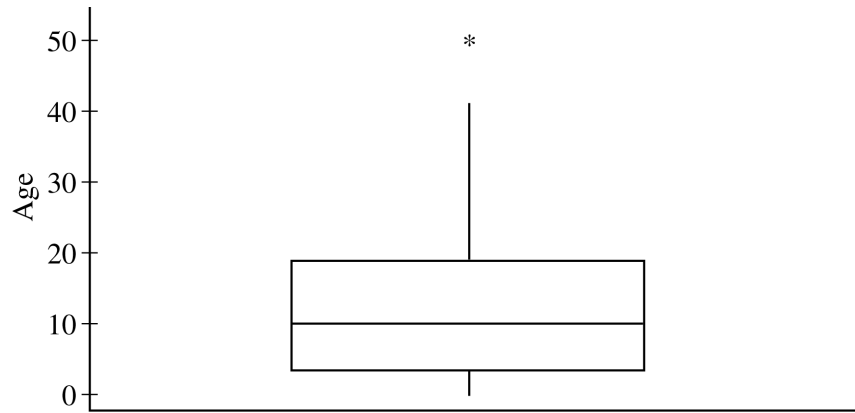
Two-Sample

Statistic	Standard Deviation of Statistic
Difference of sample means	$\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$  Special case when $\sigma_1 = \sigma_2$ $\sigma \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$
Difference of sample proportions	$\sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}$  Special case when $p_1 = p_2$ $\sqrt{p(1-p)} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$

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

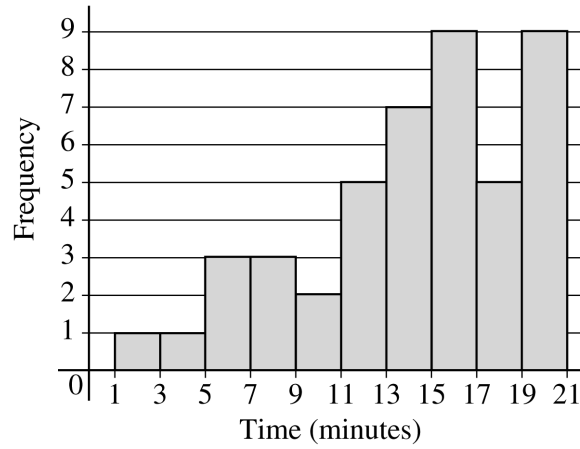


2. A random sample of 374 United States pennies was collected, and the age of each penny was determined. According to the boxplot below, what is the approximate interquartile range (IQR) of the ages?



- (A) 8
- (B) 10
- (C) 16
- (D) 40
- (E) 50

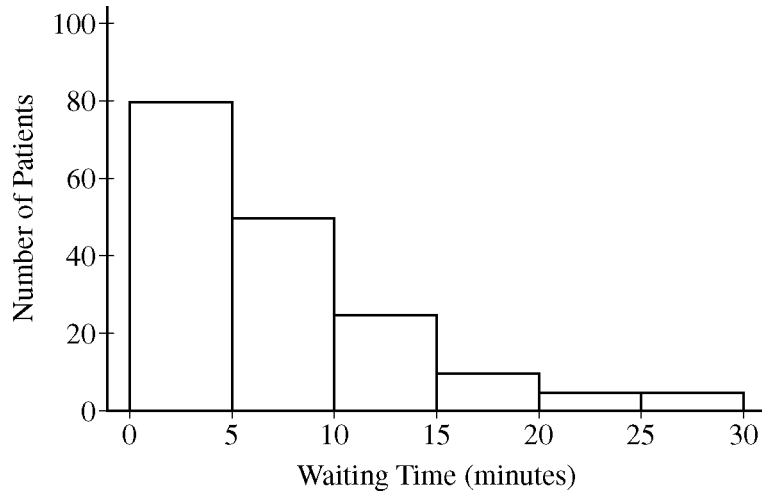




3. The histogram above shows the number of minutes needed by 45 students to finish playing a computer game. Which of the following statements is correct?
- (A) The distribution is skewed to the right.
  - (B) The distribution is skewed to the left.
  - (C) The distribution appears to be normal.
  - (D) The distribution appears to be chi-square.
  - (E) The distribution appears to be uniform.

4. A bank surveyed all of its 60 employees to determine the proportion who participate in volunteer activities. Which of the following statements is true?
- (A) The bank should not use the data from this survey because this is an observational study.
  - (B) The bank can use the result of this survey to prove that working for the bank causes employees to participate in volunteer activities.
  - (C) The bank did not select a random sample of employees, so the survey will not provide the bank with useful information.
  - (D) The bank would have to use the survey data to construct a confidence interval in order to estimate the proportion of employees who participate in volunteer activities.
  - (E) The bank does not need to use an inference procedure to determine the proportion of employees who participate in volunteer activities because the survey was a census of all employees.

5. The histogram below displays the frequencies of waiting times, in minutes, for 175 patients in a dentist's office.



Which of the following could be the median of the waiting times, in minutes?

- (A) 2.50
- (B) 7.25
- (C) 12.25
- (D) 15.00
- (E) 17.50

6. Data were collected on the amount, in dollars, that individual customers spent on dinner in an Italian restaurant. The quartiles for these data are given below.

Q1	Q2	Q3
\$36.27	\$44.27	\$58.97

Which of the following statements must be true for these customers?

- (A) At least half of the customers spent less than or equal to \$44.27 and at least half spent greater than or equal to \$44.27.
- (B) Seventy-five percent of the customers spent between \$36.27 and \$58.97.
- (C) Twenty-five percent of the customers spent less than or equal to \$58.97 and the remaining 75 percent spent greater than or equal to \$58.97.
- (D) The mean amount spent by customers is \$44.27.
- (E) A majority of customers spent \$44.27.

7. The weight of adult male grizzly bears living in the wild in the continental United States is approximately normally distributed with a mean of 500 pounds and a standard deviation of 50 pounds. The weight of adult female grizzly bears is approximately normally distributed with a mean of 300 pounds and a standard deviation of 40 pounds. Approximately, what would be the weight of a female grizzly bear with the same standardized score ( $z$ -score) as a male grizzly bear with a weight of 530 pounds?
- (A) 276 pounds
  - (B) 324 pounds
  - (C) 330 pounds
  - (D) 340 pounds
  - (E) 530 pounds

8. A company sells concrete in batches of 5 cubic yards. The probability distribution of  $X$ , the number of cubic yards sold in a single order for concrete from this company, is shown in the table below.

$X =$ the number of cubic yards	10	15	20	25	30
Probability	0.15	0.25	0.25	0.30	0.05

The expected value of the probability distribution of  $X$  is 19.25 and the standard deviation is 5.76. There is a fixed cost to deliver the concrete. The profit  $Y$ , in dollars, for a particular order can be described by  $Y = 75X - 100$ . What is the standard deviation of  $Y$ ?

- (A) \$332.00
- (B) \$432.00
- (C) \$532.00
- (D) \$1,343.75
- (E) \$1,400.00

9. Based on a survey of a random sample of 900 adults in the United States, a journalist reports that 60 percent of adults in the United States are in favor of increasing the minimum hourly wage. If the reported percent has a margin of error of 2.7 percentage points, which of the following is closest to the level of confidence?
- (A) 80.0%
  - (B) 90.0%
  - (C) 95.0%
  - (D) 95.5%
  - (E) 99.0%

10. A compact disc (CD) manufacturer wanted to determine which of two different cover designs for a newly released CD will generate more sales. The manufacturer chose 70 stores to sell the CD. Thirty-five of these stores were randomly assigned to sell CDs with one of the cover designs and the other 35 were assigned to sell the CDs with the other cover design. The manufacturer recorded the number of CDs sold at each of the stores and found a significant difference between the mean number of CDs sold for the two cover designs. Which of the following gives the conclusion that should be made based on the results and provides the best explanation for the conclusion?
- (A) It is not reasonable to conclude that the difference in sales was caused by the different cover designs because this was not an experiment.
  - (B) It is not reasonable to conclude that the difference in sales was caused by the different cover designs because there was no control group for comparison.
  - (C) It is not reasonable to conclude that the difference in sales was caused by the different cover designs because the 70 stores were not randomly chosen.
  - (D) It is reasonable to conclude that the difference in sales was caused by the different cover designs because the cover designs were randomly assigned to stores.
  - (E) It is reasonable to conclude that the difference in sales was caused by the different cover designs because the sample size was large.



11. The manager of a public swimming pool wants to compare the effectiveness of two laundry detergents, Detergent A and Detergent B, in cleaning the towels that are used daily. As each dirty towel is turned in, it is placed into the only washing machine on the premises. When the washing machine contains 20 towels, the manager flips a coin to determine whether Detergent A or Detergent B will be used for that load. The cleanliness of the load of towels is rated on a scale of 1 to 10 by a person who does not know which detergent was used. The manager continues this experiment for many days. Which of the following best describes the manager's study?
- (A) A completely randomized design
  - (B) A randomized block design with Detergent A and Detergent B as blocks
  - (C) A randomized block design with the washing machine as the block
  - (D) A matched-pairs design with Detergent A and Detergent B as the pair
  - (E) An observational study

12. In the design of a survey, which of the following best explains how to minimize response bias?

- (A) Increase the sample size.
- (B) Decrease the sample size.
- (C) Randomly select the sample.
- (D) Increase the number of questions in the survey.
- (E) Carefully word and field-test survey questions.

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13. For a sample of 42 rabbits, the mean weight is 5 pounds and the standard deviation of weights is 3 pounds. Which of the following is most likely true about the weights for the rabbits in this sample?

- (A) The distribution of weights is approximately normal because the sample size is 42, and therefore the central limit theorem applies.
- (B) The distribution of weights is approximately normal because the standard deviation is less than the mean.
- (C) The distribution of weights is skewed to the right because the least possible weight is within 2 standard deviations of the mean.
- (D) The distribution of weights is skewed to the left because the least possible weight is within 2 standard deviations of the mean.
- (E) The distribution of weights has a median that is greater than the mean.

14. When conducting a large sample test of  $H_0 : p = p_0$  for a single proportion, the test statistic is

$$z = \frac{(\hat{p} - p_0)}{\sqrt{\frac{p_0(1 - p_0)}{n}}}, \text{ where } \hat{p} \text{ is the sample proportion. Which of the following best explains the justification}$$

for the denominator of this test statistic?

- (A) The standard deviation of  $\hat{p}$  is known when the null hypothesis is true.
- (B) The standard deviation of  $\hat{p}$  is known when the alternative hypothesis is true.
- (C) The sample size is large and therefore the standard deviation of  $p_0$  is approximated well.
- (D) The standard deviation of  $p_0$  is known when the null hypothesis is true.
- (E) The standard deviation of  $p_0$  is known when the alternative hypothesis is true.

15. A polling firm is interested in surveying a representative sample of registered voters in the United States. The firm has automated its sampling so that random phone numbers within the United States are called. Each time a number is called, the procedure below is followed.

- If there is no response or if an answering machine is reached, another number is automatically called.
- If a person answers, a survey worker verifies that the person is at least 18 years of age.
- If the person is not at least 18 years of age, no response is recorded, and another number is called.
- If the person is at least 18 years of age, that person is surveyed.

Some people claim the procedure being used does not permit the results to be extended to all registered voters. Which of the following is NOT a legitimate concern about the procedure being used?

- (A) Registered voters with children under the age of 18 years may be underrepresented in the sample.
- (B) Registered voters with unlisted telephone numbers may be underrepresented in the sample.
- (C) Registered voters who have more than one telephone number may be overrepresented in the sample.
- (D) Registered voters who live in households consisting of more than one voter may be underrepresented.
- (E) People who are not registered to vote may bias the sample results.

16. A complex electronic device contains three components, A, B, and C. The probabilities of failure for each component in any one year are 0.01, 0.03, and 0.04, respectively. If any one component fails, the device will fail. If the components fail independently of one another, what is the probability that the device will not fail in one year?
- (A) Less than 0.01
  - (B) 0.078
  - (C) 0.080
  - (D) 0.922
  - (E) Greater than 0.99

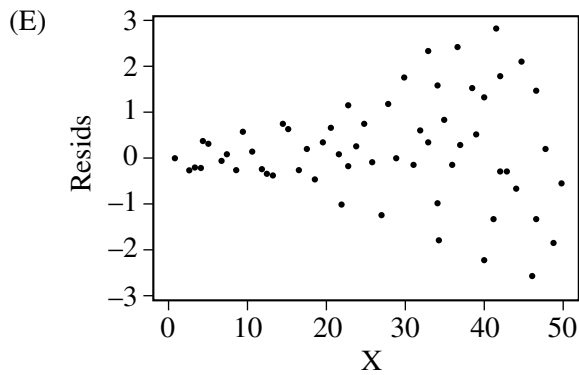
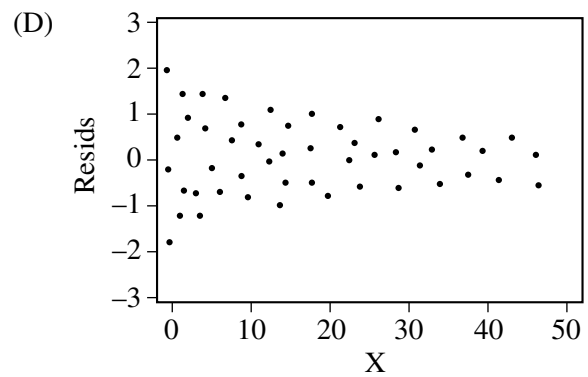
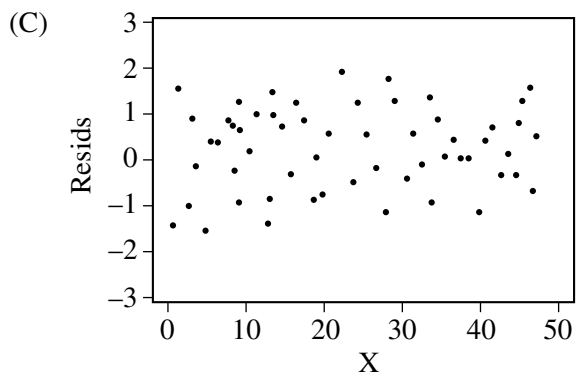
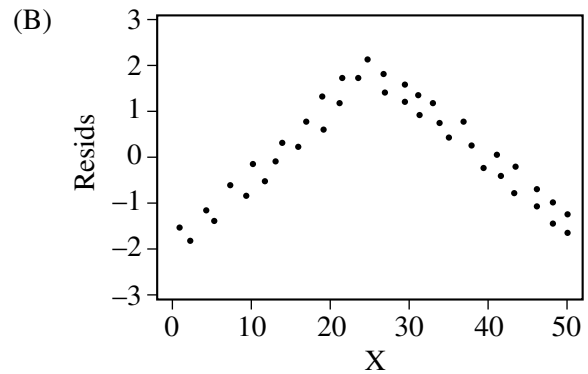
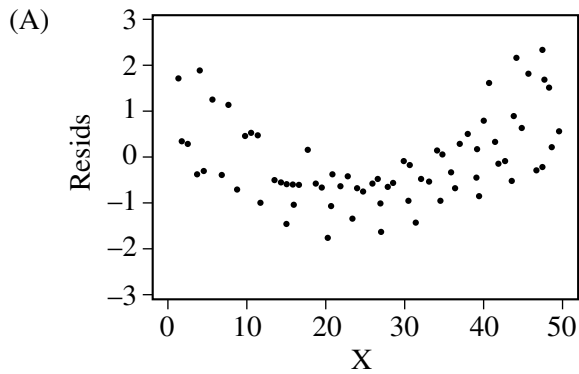
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17. A large-sample 98 percent confidence interval for the proportion of hotel reservations that are canceled on the intended arrival day is (0.048, 0.112). What is the point estimate for the proportion of hotel reservations that are canceled on the intended arrival day from which this interval was constructed?
- (A) 0.032
  - (B) 0.064
  - (C) 0.080
  - (D) 0.160
  - (E) It cannot be determined from the information given.

18. When using a one-sample  $t$ -procedure to construct a confidence interval for the mean of a finite population, a condition is that the population size be at least 10 times the sample size. The reason for the condition is to ensure that
- (A) the sample size is large enough
  - (B) the central limit theorem is applicable for the sample mean
  - (C) the sample standard deviation is a good approximation of the population standard deviation
  - (D) the degree of dependence among observations is negligible
  - (E) the sampling method is not biased

19. A nonprofit organization plans to hold a raffle to raise funds for its operations. A total of 1,000 raffle tickets will be sold for \$1.00 each. After all the tickets are sold, one ticket will be selected at random and its owner will receive \$50.00. The expected value for the net gain for each ticket is  $-\$0.95$ . What is the meaning of the expected value in this context?
- (A) The ticket owners lose an average of \$0.05 per raffle ticket.
  - (B) The ticket owners lose an average of \$0.95 per raffle ticket.
  - (C) Each ticket owner will lose \$0.95 per raffle ticket.
  - (D) A ticket owner would have to purchase 19 more tickets for the expected value of his or her net gain to increase to \$0.00.
  - (E) A ticket owner has a 95 percent chance of having a ticket that is not selected.

- 
20. Suppose that on a hypothesis test for a single population mean,  $H_a: \mu < 10$ . Assume that  $H_a$  is true. For a fixed sample size and significance level  $\alpha$ , the power of the test will be greatest if the actual mean is which of the following?
- (A) 8
  - (B) 9
  - (C) 10
  - (D) 11
  - (E) 13

21. The residual plots from five different least squares regression lines are shown below. Which of the plots provides the strongest evidence that its regression line is an appropriate model for the data and is consistent with the assumptions required for inference for regression?





22. A random sample of 50 students at a large high school resulted in a 95 percent confidence interval for the mean number of hours of sleep per day of (6.73, 7.67). Which of the following statements best summarizes the meaning of this confidence interval?
- (A) About 95% of all random samples of 50 students from this population would result in a 95% confidence interval of (6.73, 7.67).
  - (B) About 95% of all random samples of 50 students from this population would result in a 95% confidence interval that covered the population mean number of hours of sleep per day.
  - (C) 95% of the students in the survey reported sleeping between 6.73 and 7.67 hours per day.
  - (D) 95% of the students in this high school sleep between 6.73 and 7.67 hours per day.
  - (E) A student selected at random from this population sleeps between 6.73 and 7.67 hours per day for 95% of the time.

23. A local company is interested in supporting environmentally friendly initiatives such as carpooling among employees. The company surveyed all of the 200 employees at the downtown offices. Employees responded as to whether or not they own a car and to the location of the home where they live. The results are shown in the table below.

		Location of Home			
		Downtown Area In the City	Elsewhere In the City	Outside the City	Total
Car Ownership	Yes	10	15	35	60
	No	60	55	25	140
	Total	70	70	60	200

Which of the following statements about a randomly chosen person from these 200 employees is true?

- (A) If the person owns a car, he or she is more likely to live elsewhere in the city than to live in the downtown area in the city.
- (B) If the person does not own a car, he or she is more likely to live outside the city than to live in the city (downtown area or elsewhere).
- (C) The person is more likely to own a car if he or she lives in the city (downtown area or elsewhere) than if he or she lives outside the city.
- (D) The person is more likely to live in the downtown area in the city than elsewhere in the city.
- (E) The person is more likely to own a car than not to own a car.

24. A random sample of 432 voters revealed that 100 are in favor of a certain bond issue. A 95 percent confidence interval for the proportion of the population of voters who are in favor of the bond issue is

(A)  $100 \pm 1.96\sqrt{\frac{0.5(0.5)}{432}}$

(B)  $100 \pm 1.645\sqrt{\frac{0.5(0.5)}{432}}$

(C)  $100 \pm 1.96\sqrt{\frac{0.231(0.769)}{432}}$

(D)  $0.231 \pm 1.96\sqrt{\frac{0.231(0.769)}{432}}$

(E)  $0.231 \pm 1.645\sqrt{\frac{0.231(0.769)}{432}}$

25. The commuting time for a student to travel from home to a college campus is normally distributed with a mean of 30 minutes and a standard deviation of 5 minutes. If the student leaves home at 8:25 A.M., what is the probability that the student will arrive at the college campus later than 9 A.M.?
- (A) 0.16
  - (B) 0.32
  - (C) 0.50
  - (D) 0.84
  - (E) 1.00

26. In 2009 a survey of Internet usage found that 79 percent of adults age 18 years and older in the United States use the Internet. A broadband company believes that the percent is greater now than it was in 2009 and will conduct a survey. The company plans to construct a 98 percent confidence interval to estimate the current percent and wants the margin of error to be no more than 2.5 percentage points. Assuming that at least 79 percent of adults use the Internet, which of the following should be used to find the sample size ( $n$ ) needed?

(A)  $1.96\sqrt{\frac{(0.5)}{n}} \leq 0.025$

(B)  $1.96\sqrt{\frac{(0.5)(0.5)}{n}} \leq 0.025$

(C)  $2.33\sqrt{\frac{(0.5)(0.5)}{n}} \leq 0.05$

(D)  $2.33\sqrt{\frac{(0.79)(0.21)}{n}} \leq 0.025$

(E)  $2.33\sqrt{\frac{(0.79)(0.21)}{n}} \leq 0.05$

27. A manufacturer claims its Brand *A* battery lasts longer than its competitor's Brand *B* battery. Nine batteries of each brand are tested independently, and the hours of battery life are shown in the table below.

Brand <i>A</i>	88	85	80	81	72	90	85	85	84
Brand <i>B</i>	80	79	77	82	75	81	77	73	78

Provided that the assumptions for inference are met, which of the following tests should be conducted to determine if Brand *A* batteries do, in fact, last longer than Brand *B* batteries?

- (A) A one-sided, paired  $t$ -test
- (B) A one-sided, two-sample  $t$ -test
- (C) A two-sided, two-sample  $t$ -test
- (D) A one-sided, two-sample  $z$ -test
- (E) A two-sided, two-sample  $z$ -test

28. An experimenter conducted a two-tailed hypothesis test on a set of data and obtained a  $p$ -value of 0.44. If the experimenter had conducted a one-tailed test on the same set of data, which of the following is true about the possible  $p$ -value(s) that the experimenter could have obtained?
- (A) The only possible  $p$ -value is 0.22.
  - (B) The only possible  $p$ -value is 0.44.
  - (C) The only possible  $p$ -value is 0.88.
  - (D) The possible  $p$ -values are 0.22 and 0.78.
  - (E) The possible  $p$ -values are 0.22 and 0.88.

29. A randomized experiment was performed to determine whether two fertilizers, A and B, give different yields of tomatoes. A total of 33 tomato plants were grown; 16 using fertilizer A, and 17 using fertilizer B. The distributions of the data did not show marked skewness and there were no outliers in either data set. The results of the experiment are shown below.

	<u>Fertilizer A</u>	<u>Fertilizer B</u>
Average number of tomatoes per plant	19.54	23.39
Standard deviation	3.68	4.93
Number of plants	16	17

Which of the following statements best describes the conclusion that can be drawn from this experiment?

- (A) There is no statistical evidence of difference in the yields between fertilizer A and fertilizer B ( $p > 0.15$ ).
- (B) There is a borderline statistically significant difference in the yields between fertilizer A and fertilizer B ( $0.10 < p < 0.15$ ).
- (C) There is evidence of a statistically significant difference in the yields between fertilizer A and fertilizer B ( $0.05 < p < 0.10$ ).
- (D) There is evidence of a statistically significant difference in the yields between fertilizer A and fertilizer B ( $0.01 < p < 0.05$ ).
- (E) There is evidence of a statistically significant difference in the yields between fertilizer A and fertilizer B ( $p < 0.01$ ).



30. In order to plan its next advertising campaign, the Trendy Motor Vehicle Company is investigating whether the type of vehicle and the color of vehicle are related. Each person in a random sample of size 275 selected from the company's mailing list was classified according to the type (car or truck) and the color of vehicle he or she drove. The data are shown in the table below.

		Vehicle Color				
		Red	Black	White	Tan	Green
Vehicle Type	Car	35	23	41	21	12
	Truck	27	55	39	12	10

Which of the following procedures would be most appropriate to use for investigating whether there is a relationship between vehicle type and color?

- (A) A two-sample  $t$ -test
- (B) A two-sample  $z$ -test
- (C) A matched pairs  $t$ -test
- (D) A chi-square goodness-of-fit test
- (E) A chi-square test of independence

31. A large number of randomized experiments were conducted to determine whether taking a particular drug regularly would decrease the chance of getting a certain disease. For each of the experiments, the drug effect is the difference between the proportion of people taking the drug who got the disease and the proportion of people taking a placebo who got the disease. If the drug had no effect whatsoever, which of the following experimental results would be anticipated?

I.  $p$ -values will be greater than 0.05 for about 95 percent of the experiments.

II. There will be about an equal number of experiments showing positive and negative values of drug effect.

III. When 95 percent confidence intervals for the population drug effect are constructed, those confidence intervals include 0 about 95 percent of the time.

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) I, II, and III

32. As part of a class project at a large university, Amber selected a random sample of 12 students in her major field of study. All students in the sample were asked to report their number of hours spent studying for the final exam and their score on the final exam. A regression analysis on the data produced the following partial computer output.

Predictor	Coef	SE Coef	T	P
Constant	62.328	4.570	13.64	0.000
Study Hours	2.697	0.745	3.62	0.005

S = 5.505      R-sq = 56.7%

Amber wants to compute a 95 percent confidence interval for the slope of the least squares regression line in the population of all students in her major field of study. Assuming that conditions for inference are satisfied, which of the following gives the margin of error for the confidence interval?

- (A)  $(2.228)(0.745)$
- (B)  $(2.228)\left(\frac{0.745}{\sqrt{12}}\right)$
- (C)  $(2.228)(5.505)$
- (D)  $(2.228)\left(\frac{5.505}{\sqrt{12}}\right)$
- (E)  $(2.228)(2.697)$

33. A mathematics competition uses the following scoring procedure to discourage students from guessing (choosing an answer randomly) on the multiple-choice questions. For each correct response, the score is 7. For each question left unanswered, the score is 2. For each incorrect response, the score is 0. If there are 5 choices for each question, what is the minimum number of choices that the student must eliminate before it is advantageous to guess among the rest?
- (A) 0
  - (B) 1
  - (C) 2
  - (D) 3
  - (E) 4

- 
34. The probability that a new microwave oven will stop working in less than 2 years is 0.05. The probability that a new microwave oven is damaged during delivery and stops working in less than 2 years is 0.04. The probability that a new microwave oven is damaged during delivery is 0.10. Given that a new microwave oven is damaged during delivery, what is the probability that it stops working in less than 2 years?
- (A) 0.05
  - (B) 0.06
  - (C) 0.10
  - (D) 0.40
  - (E) 0.50

35. Perchlorate is a chemical used in rocket fuel. People who live near a former rocket-testing site are concerned that perchlorate is present in unsafe amounts in their drinking water. Drinking water is considered safe when the average level of perchlorate is 24.5 parts per billion (ppb) or less. A random sample of 28 water sources in this area produces a mean perchlorate measure of 25.3 ppb. Which of the following is an appropriate alternative hypothesis that addresses their concern?

(A)  $H_a : \mu < 25.3$

(B)  $H_a : \mu > 25.3$

(C)  $H_a : \mu < 24.5$

(D)  $H_a : \mu > 24.5$

(E)  $H_a : \mu \neq 24.5$

36. The computer output below shows the result of a linear regression analysis for predicting the concentration of zinc, in parts per million (ppm), from the concentration of lead, in ppm, found in fish from a certain river.

Response variable is Zinc (ppm)				
Variable	Coefficient	Std Dev	T	P
Constant	16.3	4.90	3.32	0.003
Lead (ppm)	19.0	1.89	10.01	0.000

S = 16.17    R-Sq = 82.0%

Which of the following statements is a correct interpretation of the value 19.0 in the output?

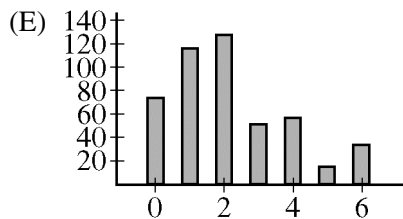
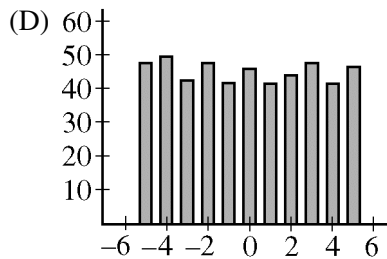
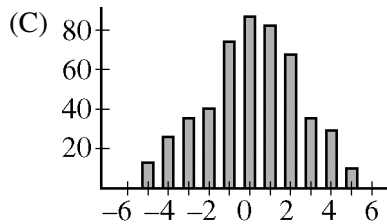
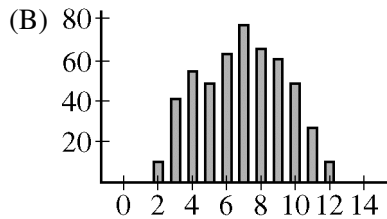
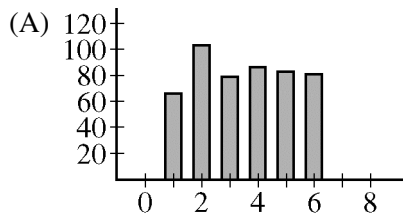
- (A) On average there is a predicted increase of 19.0 ppm in concentration of lead for every increase of 1 ppm in concentration of zinc found in the fish.
- (B) On average there is a predicted increase of 19.0 ppm in concentration of zinc for every increase of 1 ppm in concentration of lead found in the fish.
- (C) The predicted concentration of zinc is 19.0 ppm in fish with no concentration of lead.
- (D) The predicted concentration of lead is 19.0 ppm in fish with no concentration of zinc.
- (E) Approximately 19% of the variability in zinc concentration is predicted by its linear relationship with lead concentration.

37. There were 5,317 previously owned homes sold in a western city in the year 2000. The distribution of the sales prices of these homes was strongly right-skewed, with a mean of \$206,274 and a standard deviation of \$37,881. If all possible simple random samples of size 100 are drawn from this population and the mean is computed for each of these samples, which of the following describes the sampling distribution of the sample mean?
- (A) Approximately normal with mean \$206,274 and standard deviation \$3,788
  - (B) Approximately normal with mean \$206,274 and standard deviation \$37,881
  - (C) Approximately normal with mean \$206,274 and standard deviation \$520
  - (D) Strongly right-skewed with mean \$206,274 and standard deviation \$3,788
  - (E) Strongly right-skewed with mean \$206,274 and standard deviation \$37,881

38. A physician believes that the exercise habits of East Coast adults are different from the exercise habits of West Coast adults. To study this, she gathers information on the number of hours of exercise per week from a random sample of East Coast adults and a random sample of West Coast adults. Which of the following might be an appropriate null hypothesis for this study?
- (A) The average number of hours of exercise per week for East Coast adults is different from the average number of hours of exercise per week for West Coast adults.
  - (B) The average number of hours of exercise per week for East Coast adults is the same as the average number of hours of exercise per week for West Coast adults.
  - (C) The average number of hours of exercise per week for East Coast adults is greater than the average number of hours of exercise per week for West Coast adults.
  - (D) The average number of hours of exercise per week for East Coast adults is less than the average number of hours of exercise per week for West Coast adults.
  - (E) The probability is 0.5 that an East Coast adult and a West Coast adult exercise an equal number of hours per week.



39. For a roll of a fair die, each of the outcomes 1, 2, 3, 4, 5, or 6 is equally likely. A red die and a green die are rolled simultaneously, and the difference of the outcomes (red – green) is computed. This is repeated for a total of 500 rolls of the pair of dice. Which of the following graphs best represents the most reasonable distribution of the differences?



40. The probability of winning a certain game is 0.5. If at least 70 percent of the games in a series of  $n$  games are won, the player wins a prize. If the possible choices for  $n$  are

$$n=10, n=20, \text{ and } n=100,$$

which value of  $n$  should the player choose in order to maximize the probability of winning a prize?

- (A)  $n=10$  only
- (B)  $n=20$  only
- (C)  $n=100$  only
- (D)  $n=10$  or  $n=20$  only; the probabilities are the same.
- (E)  $n=10$  or  $n=20$  or  $n=100$ ; the probabilities are the same.

**END OF SECTION I**

**IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY  
CHECK YOUR WORK ON THIS SECTION.**

**DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.**

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**MAKE SURE YOU HAVE DONE THE FOLLOWING.**

- **PLACED YOUR AP NUMBER LABEL ON YOUR ANSWER SHEET**
- **WRITTEN AND GRIDDED YOUR AP NUMBER CORRECTLY ON YOUR ANSWER SHEET**
- **TAKEN THE AP EXAM LABEL FROM THE FRONT OF THIS BOOKLET AND PLACED IT ON YOUR ANSWER SHEET**

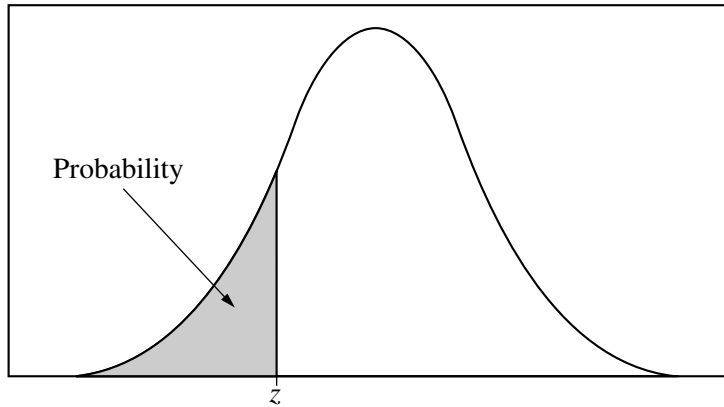


Table entry for  $z$  is the probability lying below  $z$ .

**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

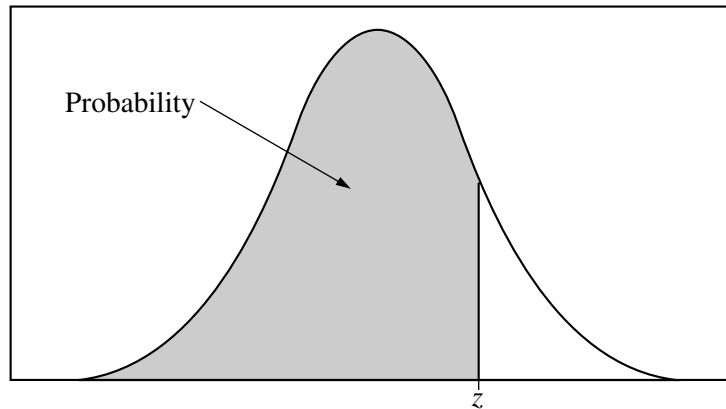
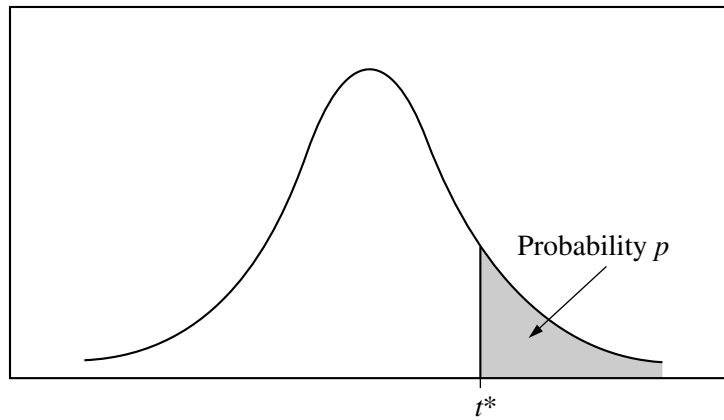


Table entry for  $z$  is the probability lying below  $z$ .

**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

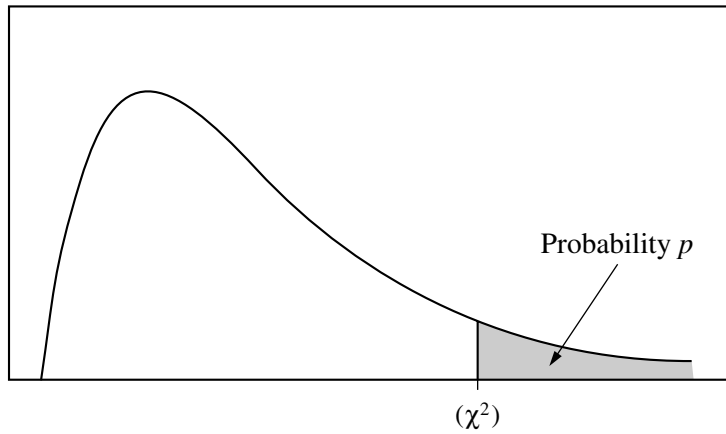
Table entry for  $p$  and  $C$  is the point  $t^*$  with probability  $p$  lying above it and probability  $C$  lying between  $-t^*$  and  $t^*$ .



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

df	Tail probability $p$											
	.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
$\infty$	.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 ( $\chi^2$ ) with probability  $p$  lying above it.



**Table C**  $\chi^2$  critical values

df	Tail probability $p$											
	.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

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## **Section II: Free-Response Questions**

This is the free-response section of the 2012 AP exam. It includes cover material and other administrative instructions to help familiarize students with the mechanics of the exam. (Note that future exams may differ in look from the following content.)

# AP<sup>®</sup> Statistics Exam

## SECTION II: Free Response

2012

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

### At a Glance

**Total Time**

1 hour, 30 minutes

**Number of Questions**

6

**Percent of Total Score**

50%

**Writing Instrument**

Either pencil or pen with black or dark blue ink

**Electronic Device**

Graphing calculator expected

### Part A

**Number of Questions**

5

**Suggested Time**

1 hour, 5 minutes

**Percent of Section II Score**

75%

### Part B

**Number of Questions**

1

**Suggested Time**

25 minutes

**Percent of Section II Score**

25%

### IMPORTANT Identification Information

PLEASE PRINT WITH PEN:

1. First two letters of your last name   
First letter of your first name
2. Date of birth  
    
Month Day Year
3. Six-digit school code
4. Unless I check the box below, I grant the College Board the unlimited right to use, reproduce, and publish my free-response materials, both written and oral, for educational research and instructional purposes. My name and the name of my school will not be used in any way in connection with my free-response materials. I understand that I am free to mark "No" with no effect on my score or its reporting.  
No, I do not grant the College Board  these rights.

### Instructions

The questions for both Part A and Part B are printed in this booklet. You may use any blank space in the booklet to organize your answers and for scratch work, but you must write your answers in the spaces provided for each answer. Pages containing statistical tables and useful formulas are printed in this booklet.

You may wish to look over the questions before starting to work on them. It is not expected that everyone will be able to complete all parts of all questions. Show all your work. Indicate clearly the methods you use because you will be scored on the correctness of your methods as well as the accuracy and completeness of your results and explanations. Correct answers without supporting work may not receive credit. Write your solution to each part of each question in the space provided for that part. Write clearly and legibly. Cross out any errors you make; erased or crossed-out work will not be scored.

Manage your time carefully. The proctor will announce the suggested time for Part A and Part B, but you may proceed freely from one question to the next. You may review your responses if you finish before the end of the exam is announced.



Minimum 20% post-consumer waste

Form I  
Form Code 4IBP-S2

90



Formulas begin on page 3.  
Questions begin on page 6.  
Tables begin on page 18.

## Formulas

(I) Descriptive Statistics

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

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

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

$$\hat{y} = b_0 + b_1x$$

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

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

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

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

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

(II) Probability

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

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

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

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

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  $\bar{x}$  is the mean of a random sample of size  $n$  from an infinite population with mean  $\mu$  and standard deviation  $\sigma$ , then:

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

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

(III) Inferential Statistics

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

Confidence interval:  $\text{statistic} \pm (\text{critical value}) \cdot (\text{standard deviation of statistic})$

Single-Sample

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

Two-Sample

Statistic	Standard Deviation of Statistic
Difference of sample means	$\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$ <p>Special case when <math>\sigma_1 = \sigma_2</math></p> $\sigma \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$
Difference of sample proportions	$\sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}$ <p>Special case when <math>p_1 = p_2</math></p> $\sqrt{p(1-p)} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$

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

**STATISTICS**

**SECTION II**

**Part A**

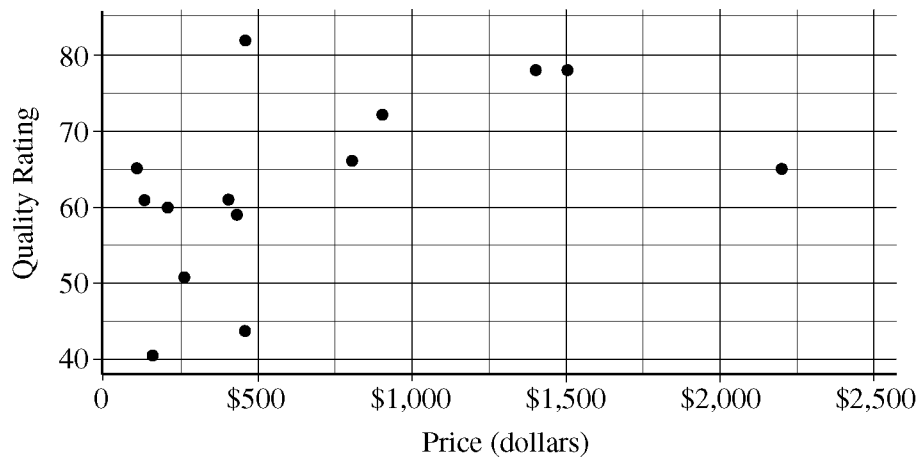
**Questions 1-5**

**Spend about 65 minutes on this part of the exam.**

**Percent of Section II score—75**

**Directions:** Show all your work. Indicate clearly the methods you use, because you will be scored on the correctness of your methods as well as on the accuracy and completeness of your results and explanations.

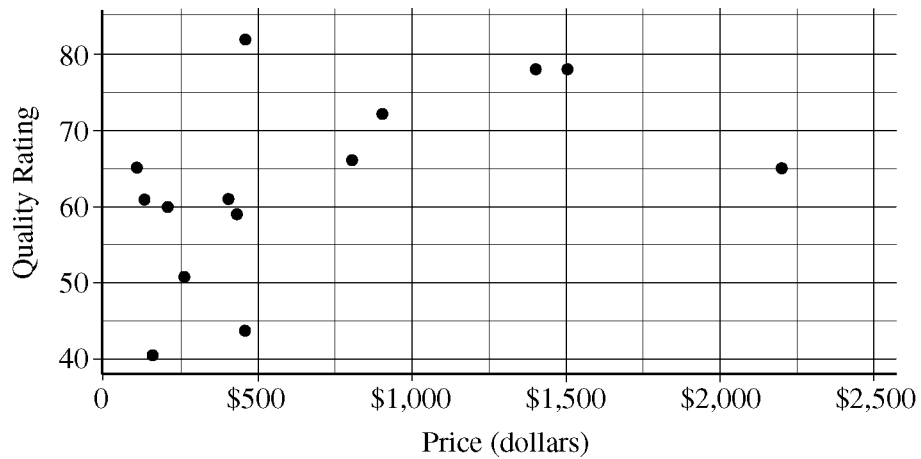
1. The scatterplot below displays the price in dollars and quality rating for 14 different sewing machines.



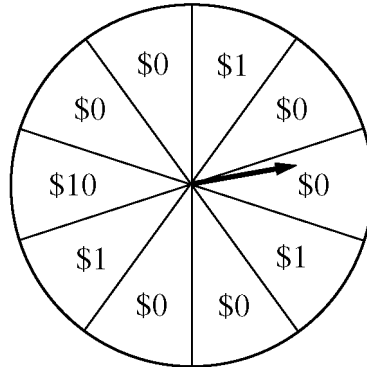
- (a) Describe the nature of the association between price and quality rating for the sewing machines.

(b) One of the 14 sewing machines substantially affects the appropriateness of using a linear regression model to predict quality rating based on price. Report the approximate price and quality rating of that machine and explain your choice.

(c) Chris is interested in buying one of the 14 sewing machines. He will consider buying only those machines for which there is no other machine that has both higher quality and lower price. On the scatterplot reproduced below, circle all data points corresponding to machines that Chris will consider buying.



2. A charity fundraiser has a Spin the Pointer game that uses a spinner like the one illustrated in the figure below.



A donation of \$2 is required to play the game. For each \$2 donation, a player spins the pointer once and receives the amount of money indicated in the sector where the pointer lands on the wheel. The spinner has an equal probability of landing in each of the 10 sectors.

(a) Let  $X$  represent the net contribution to the charity when one person plays the game once. Complete the table for the probability distribution of  $X$ .

$x$	\$2	\$1	-\$8
$P(x)$			

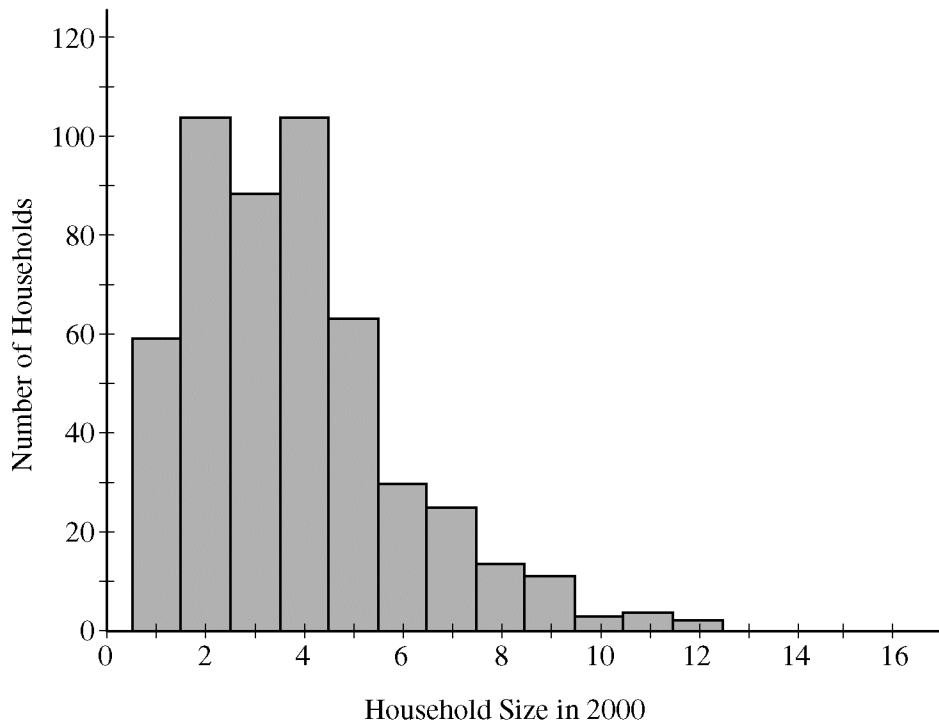
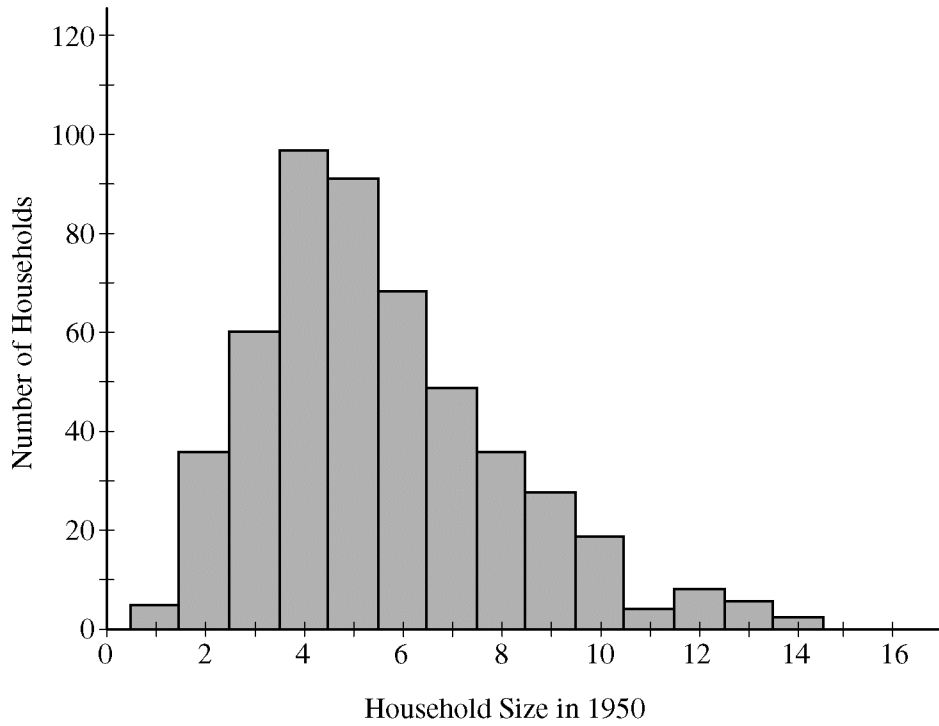
(b) What is the expected value of the net contribution to the charity for one play of the game?

(c) The charity would like to receive a net contribution of \$500 from this game. What is the fewest number of times the game must be played for the expected value of the net contribution to be at least \$500 ?

(d) Based on last year's event, the charity anticipates that the Spin the Pointer game will be played 1,000 times. The charity would like to know the probability of obtaining a net contribution of at least \$500 in 1,000 plays of the game. The mean and standard deviation of the net contribution to the charity in 1,000 plays of the game are \$700 and \$92.79, respectively. Use the normal distribution to approximate the probability that the charity would obtain a net contribution of at least \$500 in 1,000 plays of the game.



3. Independent random samples of 500 households were taken from a large metropolitan area in the United States for the years 1950 and 2000. Histograms of household size (number of people in a household) for the years are shown below.



(a) Compare the distributions of household size in the metropolitan area for the years 1950 and 2000.

(b) A researcher wants to use these data to construct a confidence interval to estimate the change in mean household size in the metropolitan area from the year 1950 to the year 2000. State the conditions for using a two-sample  $t$ -procedure, and explain whether the conditions for inference are met.

4. A survey organization conducted telephone interviews in December 2008 in which 1,009 randomly selected adults in the United States responded to the following question.

At the present time, do you think television commercials are an effective way to promote a new product?

Of the 1,009 adults surveyed, 676 responded “yes.” In December 2007, 622 of 1,020 randomly selected adults in the United States had responded “yes” to the same question. Do the data provide convincing evidence that the proportion of adults in the United States who would respond “yes” to the question changed from December 2007 to December 2008 ?

5. A recent report stated that less than 35 percent of the adult residents in a certain city will be able to pass a physical fitness test. Consequently, the city's Recreation Department is trying to convince the City Council to fund more physical fitness programs. The council is facing budget constraints and is skeptical of the report. The council will fund more physical fitness programs only if the Recreation Department can provide convincing evidence that the report is true.

The Recreation Department plans to collect data from a sample of 185 adult residents in the city. A test of significance will be conducted at a significance level of  $\alpha = 0.05$  for the following hypotheses.

$$H_0 : p = 0.35$$

$$H_a : p < 0.35,$$

where  $p$  is the proportion of adult residents in the city who are able to pass the physical fitness test.

- (a) Describe what a Type II error would be in the context of the study, and also describe a consequence of making this type of error.

- (b) The Recreation Department recruits 185 adult residents who volunteer to take the physical fitness test. The test is passed by 77 of the 185 volunteers, resulting in a  $p$ -value of 0.97 for the hypotheses stated above. If it was reasonable to conduct a test of significance for the hypotheses stated above using the data collected from the 185 volunteers, what would the  $p$ -value of 0.97 lead you to conclude?

- (c) Describe the primary flaw in the study described in part (b), and explain why it is a concern.

**STATISTICS**

**SECTION II**

**Part B**

**Question 6**

**Spend about 25 minutes on this part of the exam.**

**Percent of Section II score—25**

**Directions:** Show all your work. Indicate clearly the methods you use, because you will be scored on the correctness of your methods as well as on the accuracy and completeness of your results and explanations.

6. Two students at a large high school, Peter and Rania, wanted to estimate  $\mu$ , the mean number of soft drinks that a student at their school consumes in a week. A complete roster of the names and genders for the 2,000 students at their school was available. Peter selected a simple random sample of 100 students. Rania, knowing that 60 percent of the students at the school are female, selected a simple random sample of 60 females and an independent simple random sample of 40 males. Both asked all of the students in their samples how many soft drinks they typically consume in a week.
- (a) Describe a method Peter could have used to select a simple random sample of 100 students from the school.

Peter and Rania conducted their studies as described. Peter used the sample mean  $\bar{X}$  as a point estimator for  $\mu$ . Rania used  $\bar{X}_{\text{overall}} = (0.6)\bar{X}_{\text{female}} + (0.4)\bar{X}_{\text{male}}$  as a point estimator for  $\mu$ , where  $\bar{X}_{\text{female}}$  is the mean of the sample of 60 females and  $\bar{X}_{\text{male}}$  is the mean of the sample of 40 males.

Summary statistics for Peter's data are shown in the table below.

Variable	N	Mean	Standard Deviation
Number of soft drinks	100	5.32	4.13

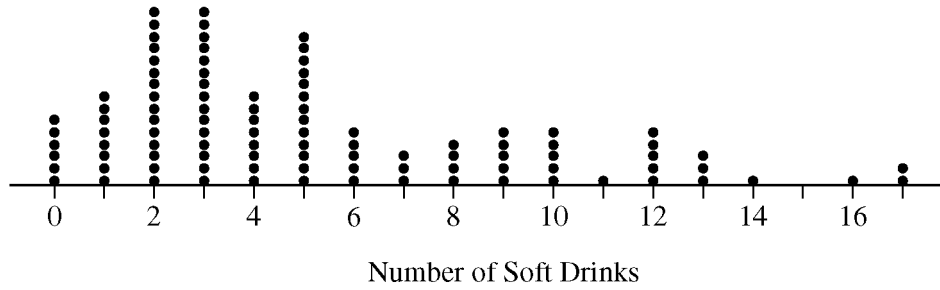
- (b) Based on the summary statistics, calculate the estimated standard deviation of the sampling distribution (sometimes called the standard error) of Peter's point estimator  $\bar{X}$ .

Summary statistics for Rania's data are shown in the table below.

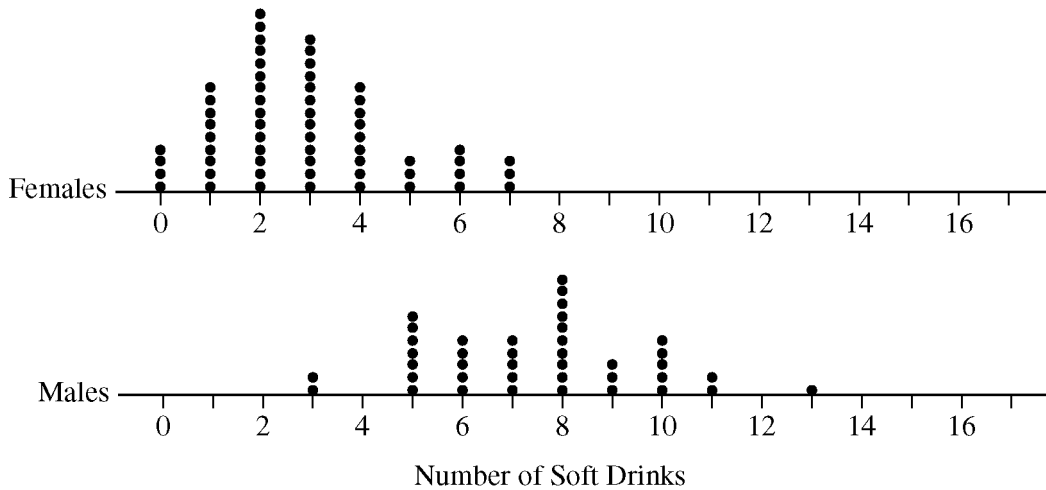
Variable	Gender	N	Mean	Standard Deviation
Number of soft drinks	Female	60	2.90	1.80
	Male	40	7.45	2.22

- (c) Based on the summary statistics, calculate the estimated standard deviation of the sampling distribution of Rania's point estimator  $\bar{X}_{\text{overall}} = (0.6)\bar{X}_{\text{female}} + (0.4)\bar{X}_{\text{male}}$ .

A dotplot of Peter's sample data is given below.



Comparative dotplots of Rania's sample data are given below.



(d) Using the dotplots above, explain why Rania's point estimator has a smaller estimated standard deviation than the estimated standard deviation of Peter's point estimator.

**STOP**

**END OF EXAM**

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**THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET.**

- **MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT AND BACK COVERS OF THE SECTION II BOOKLET.**
- **CHECK TO SEE THAT YOUR AP NUMBER LABEL APPEARS IN THE BOX(ES) ON THE COVER(S).**
- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMS YOU HAVE TAKEN THIS YEAR.**



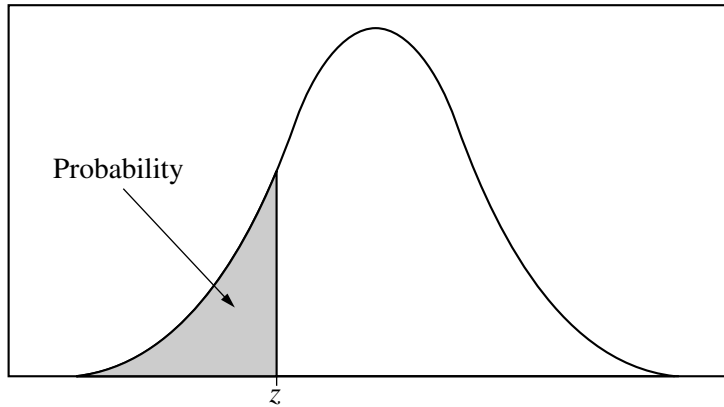


Table entry for  $z$  is the probability lying below  $z$ .

**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

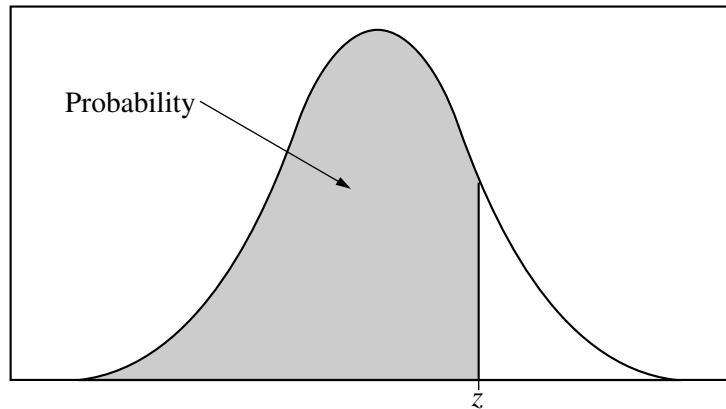
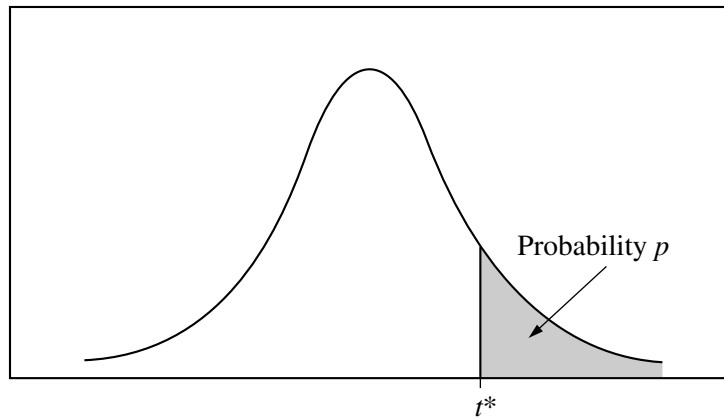


Table entry for  $z$  is the probability lying below  $z$ .

**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

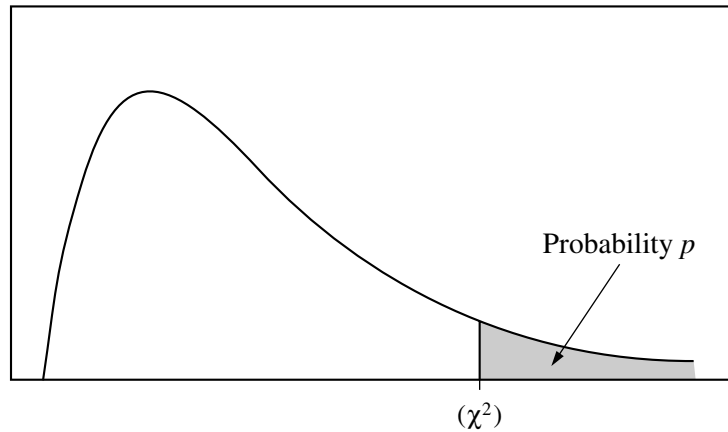
Table entry for  $p$  and  $C$  is the point  $t^*$  with probability  $p$  lying above it and probability  $C$  lying between  $-t^*$  and  $t^*$ .



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

df	Tail probability $p$											
	.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
$\infty$	.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 ( $\chi^2$ ) with probability  $p$  lying above it.



**Table C**  $\chi^2$  critical values

df	Tail probability $p$											
	.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