CollegeBoard

AP® Statistics Practice Exam

From the 2016 Administration

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AP® Statistics Exam

SECTION I: Multiple Choice

2016

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) 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.

Form I
Form Code 4MBP4-S

90

Formulas

(I) Descriptive Statistics

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

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

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

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

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

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

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

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

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

(II) Probability

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

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

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

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

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

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

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

(III) Inferential Statistics

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

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

Single-Sample

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

Two-Sample

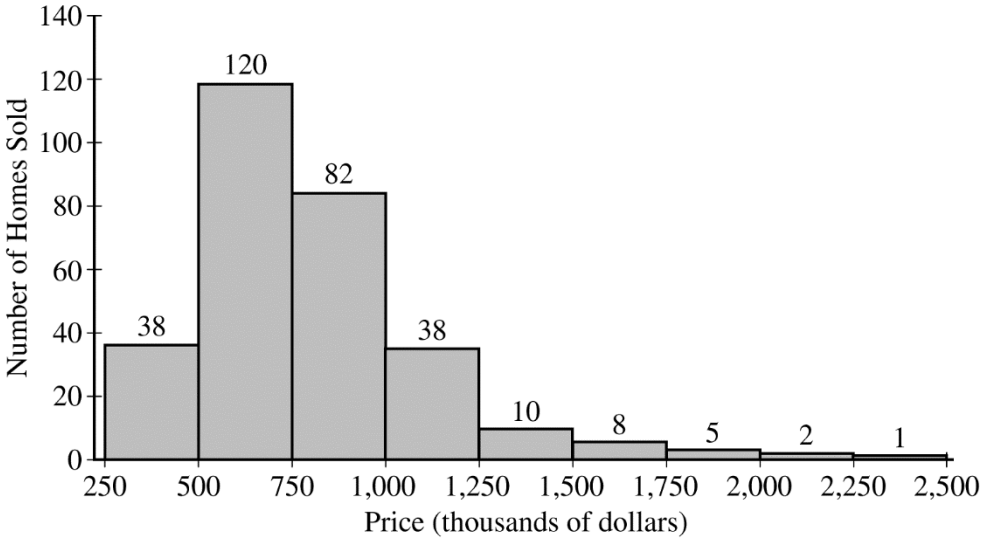
Statistic	Standard Deviation of Statistic
Difference of sample means	$\sqrt{\dfrac{\sigma_1^2}{n_1} + \dfrac{\sigma_2^2}{n_2}}$ Special case when $\sigma_1 = \sigma_2$ $\sigma\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}$
Difference of sample proportions	$\sqrt{\dfrac{p_1(1-p_1)}{n_1} + \dfrac{p_2(1-p_2)}{n_2}}$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

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

STATISTICS
SECTION I
Time—1 hour and 30 minutes
Number of questions—40
Percent of total score—50

Directions: Solve each of the following problems, using the available space for scratch work. Decide which is the best of the choices given and fill in the corresponding circle 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. The prices, in thousands of dollars, of 304 homes recently sold in a city are summarized in the histogram below.



Based on the histogram, which of the following statements must be true?

(A) The minimum price is $250,000.

(B) The maximum price is $2,500,000.

(C) The median price is not greater than $750,000.

(D) The mean price is between $500,000 and $750,000.

(E) The upper quartile of the prices is greater than $1,500,000.

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2. As part of a study on the relationship between the use of tanning booths and the occurrence of skin cancer, researchers reviewed the medical records of 1,436 people. The table below summarizes tanning booth use for people in the study who did and did not have skin cancer.

	Used a Tanning Booth	Did Not Use a Tanning Booth	Total
Skin cancer	190	706	896
No skin cancer	75	465	540
Total	265	1,171	1,436

Of the people in the study who had skin cancer, what fraction used a tanning booth?

(A) $\frac{190}{265}$

(B) $\frac{190}{896}$

(C) $\frac{190}{1,436}$

(D) $\frac{265}{1,436}$

(E) $\frac{896}{1,436}$

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3. A researcher is conducting a study of charitable donations by surveying a simple random sample of households in a certain city. The researcher wants to determine whether there is convincing statistical evidence that more than 50 percent of households in the city gave a charitable donation in the past year. Let p represent the proportion of all households in the city that gave a charitable donation in the past year. Which of the following are appropriate hypotheses for the researcher?

(A) $H_0 : p = 0.5$ and $H_a : p > 0.5$

(B) $H_0 : p = 0.5$ and $H_a : p \neq 0.5$

(C) $H_0 : p = 0.5$ and $H_a : p < 0.5$

(D) $H_0 : p > 0.5$ and $H_a : p \neq 0.5$

(E) $H_0 : p > 0.5$ and $H_a : p = 0.5$

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4. A company determines the mean and standard deviation of the number of sick days taken by its employees in one year. Which of the following is the best description of the standard deviation?

(A) Approximately the mean distance between the number of sick days taken by individual employees and the mean number of sick days taken by all employees

(B) Approximately the median distance between the number of sick days taken by individual employees and the median number of sick days taken by all employees

(C) The distance between the greatest number of sick days taken by an employee and the mean number of sick days taken by all employees

(D) The number of days separating the fewest sick days taken and the most sick days taken when considering all employees

(E) The number of days separating the fewest sick days taken and the most sick days taken when considering the middle 50 percent of the distribution

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5. In one region of the country, the mean length of stay in hospitals is 5.5 days with standard deviation 2.6 days. Because many patients stay in the hospital for considerably more days, the distribution of length of stay is strongly skewed to the right. Consider random samples of size 100 taken from the distribution with the mean length of stay, $\bar{x}$, recorded for each sample. Which of the following is the best description of the sampling distribution of $\bar{x}$?

   (A) Strongly skewed to the right with mean 5.5 days and standard deviation 2.6 days

   (B) Strongly skewed to the right with mean 5.5 days and standard deviation 0.26 day

   (C) Strongly skewed to the right with mean 5.5 days and standard deviation 0.026 day

   (D) Approximately normal with mean 5.5 days and standard deviation 2.6 days

   (E) Approximately normal with mean 5.5 days and standard deviation 0.26 day

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6. A local television news station includes a viewer survey question about a current issue at the beginning of every evening news broadcast. Viewers are invited to use social media to respond to the question. The results of the survey are shared with the audience at the end of each broadcast. In relation to the opinions of the population of the region, which of the following is a possible reason why the results of such surveys could be biased?

   I. Viewers with strong opinions about the current issue are more likely to respond than are viewers without strong opinions.
   II. The opinions of viewers of one television station are not necessarily representative of the population of a region.
   III. Viewers with access to social media are not necessarily representative of the population of a region.

   (A) I only

   (B) II only

   (C) III only

   (D) II and III only

   (E) I, II, and III

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7. A graduate student conducted a study of field mice in rural Kansas. The student obtained a sample of 100 field mice and recorded the weight, in grams, of each mouse. After the measurements were taken, it was discovered that the scale was not calibrated correctly. The student adjusted the 100 recorded measurements by subtracting 3 grams from each measurement. Which of the following statistics for the weight, in grams, of the field mice has the same value before and after the adjustment?

   (A) The median

   (B) The mean

   (C) The first quartile

   (D) The third quartile

   (E) The interquartile range

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8. A statistician proposed a new method for constructing a 90 percent confidence interval to estimate the median of assessed home values for homes in a large community. To test the method, the statistician will conduct a simulation by selecting 10,000 random samples of the same size from the population. For each sample, a confidence interval will be constructed using the new method. If the confidence level associated with the new method is actually 90 percent, which of the following will be captured by approximately 9,000 of the confidence intervals constructed from the simulation?

(A) The sample mean

(B) The sample median

(C) The sample standard deviation

(D) The population mean

(E) The population median

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9. The distribution of monthly rent for one-bedroom apartments in a city is approximately normal with mean $936 and standard deviation $61. A graduate student is looking for a one-bedroom apartment and wants to pay no more than $800 in monthly rent. Of the following, which is the best estimate of the percent of one-bedroom apartments in the city with a monthly rent of at most $800 ?

(A) 1.3%

(B) 2.5%

(C) 50%

(D) 95%

(E) 97.5%

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10. A news article reported that college students who have part-time jobs work an average of 15 hours per week. The staff of a college newspaper thought that the average might be different from 15 hours per week for their college. Data were collected on the number of hours worked per week for a random sample of students at the college who have part-time jobs. The data were used to test the hypotheses

$$H_0 : \mu = 15$$
$$H_a : \mu \neq 15,$$

where μ is the mean number of hours worked per week for all students at the college with part-time jobs. The results of the test are shown in the table below.

Sample Mean	Std Error	df	*t*-stat	*p*-value
13.755	0.707	25	−1.761	0.090

Assuming all conditions for inference were met, which of the following represents a 95 percent confidence interval for μ ?

(A) 13.755 ± 0.244

(B) 13.755 ± 0.286

(C) 13.755 ± 0.707

(D) 13.755 ± 1.245

(E) 13.755 ± 1.456

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11. A team of psychologists studied the effect of multitasking on the completion of cognitive tasks. A group of 40 women participated in the study. Each woman owned a smartphone equipped with the same type of keyboard. The women typed a text passage on the phone twice, one time while sitting in a quiet room (a single task) and the other time while walking (a multitask). The order of the single task and the multitask was randomly determined for each woman. The psychologists recorded the time it took each woman to type the text for both tasks. If the conditions of inference are met, which of the following tests is most appropriate to analyze the data?

(A) A two-sample t-test for a difference between means

(B) A matched-pairs t-test for a mean difference

(C) A one-sample z-test for a proportion

(D) A two-sample z-test for a difference between proportions

(E) A chi-square test of independence

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12. The random variable X is normally distributed with mean 5 and standard deviation 25. The random variable Y is defined by $Y = 2 + 4X$. What are the mean and the standard deviation of Y?

(A) The mean is 20 and the standard deviation is 102.

(B) The mean is 20 and the standard deviation is 50.

(C) The mean is 22 and the standard deviation is 102.

(D) The mean is 22 and the standard deviation is 100.

(E) The mean is 22 and the standard deviation is 50.

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13. In northwest Pennsylvania, a zoologist recorded the ages, in months, of 55 bears and whether each bear was male or female. The data are shown in the back-to-back stemplot below.

Female		Male
4	15	
	14	
2 0	13	
	12	
	11	
	10	
4	9	
2	8	
1	7	0
1 0	6	6
8 3 2	5	3 5
6 5 4 2 1	4	6
8 8 5 4 3 2	3	2 4 7 8
9 7 6 2 1 0 0	2	0 0 1 2 2 3 4 4 4 5 6 7 7 9
	1	5 7 8

7|0 represents 70 months

Based on the stemplot, which of the following statements is true?

(A) The median age and the range of ages are both greater for female bears than for male bears.

(B) The median age and the range of ages are both less for female bears than for male bears.

(C) The median age is the same for female bears and male bears, and the range of ages is the same for female bears and male bears.

(D) The median age is less for female bears than for male bears, and the range of ages is greater for female bears than for male bears.

(E) The median age is greater for female bears than for male bears, and the range of ages is less for female bears than for male bears.

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14. A produce supplier ships boxes of produce to individual customers. The distribution of weights of shipped boxes is approximately normal with mean 36 pounds and standard deviation 4 pounds. Which expression represents the weight, in pounds, at the 75th percentile of the distribution?

(A) $-1.96(4) + 36$

(B) $-0.25(4) + 36$

(C) $0.25(4) + 36$

(D) $0.67(4) + 36$

(E) $0.75(4) + 36$

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15. A polling agency conducted a survey by selecting 100 random samples, each consisting of 1,200 United States citizens. The citizens in each sample were asked whether they were optimistic about the economy. For each sample, the polling agency created a 95 percent confidence interval for the proportion of all United States citizens who were optimistic about the economy. Which of the following statements is the best interpretation of the 95 percent confidence level?

(A) With 100 confidence intervals, we can be 95% confident that the sample proportion of citizens of the United States who are optimistic about the economy is correct.

(B) We would expect about 95 of the 100 confidence intervals to contain the proportion of all citizens of the United States who are optimistic about the economy.

(C) We would expect about 5 of the 100 confidence intervals to not contain the sample proportion of citizens of the United States who are optimistic about the economy.

(D) Of the 100 confidence intervals, 95 of the intervals will be identical because they were constructed from samples of the same size of 1,200.

(E) The probability is 0.95 that 100 confidence intervals will yield the same information about the sample proportion of citizens of the United States who are optimistic about the economy.

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16. As part of a national sleep study, a random sample of adults was selected and surveyed about their physical activity and the number of hours they sleep each night. Of the 183 adults who exercised regularly (exercisers), 59 percent reported sleeping at least seven hours at night. Of the 88 adults who did not exercise regularly (nonexercisers), 52 percent reported sleeping at least seven hours at night. Which of the following is the most appropriate standard error for a confidence interval for the difference in proportions of adults who sleep at least seven hours at night among exercisers and nonexercisers?

(A) $\sqrt{\frac{(0.59)(0.41)}{183} + \frac{(0.52)(0.48)}{88}}$

(B) $\sqrt{\frac{(0.59)(0.41) + (0.52)(0.48)}{183 + 88}}$

(C) $\sqrt{(0.57)(0.43)\left(\frac{1}{183} + \frac{1}{88}\right)}$

(D) $\sqrt{(0.5)(0.5)\left(\frac{1}{183} + \frac{1}{88}\right)}$

(E) $\sqrt{(0.5)(0.5)\left(\frac{1+1}{183 + 88}\right)}$

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17. A representative of a car manufacturer in the United States made the following claim in a news report.

> Ten years ago, only 53 percent of Americans owned American-made cars, but that figure is significantly higher today.

A research group conducted a study to investigate whether the claim was true. The group found that 56 percent of a randomly selected sample of car owners in the United States owned American-made cars. A test of the appropriate hypotheses resulted in a p-value of 0.283. Assuming the conditions for inference were met, is there sufficient evidence to conclude, at the significance level of $\alpha = 0.05$, that the proportion of all car owners in the United States who own American-made cars has increased from what it was ten years ago?

(A) Yes, because $0.56 > 0.53$.

(B) Yes, because a reasonable interval for the proportion is 0.56 ± 0.283.

(C) Yes, because $0.56 - 0.53 = 0.03$ and $0.03 < 0.05$.

(D) No, because $0.283 < 0.53$.

(E) No, because $0.283 > 0.05$.

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18. Researchers wanted to investigate whether babies have a sense of right and wrong. They showed each of 60 babies a puppet show in which a red puppet was trying to open a heavy box lid. A second puppet, called the helper, would try to help the red puppet open the box, while a third puppet, called the hinderer, would try to slam the box lid down. After watching the show, each baby was presented with a tray containing the helper puppet and the hinderer puppet, and the researchers recorded which puppet the baby reached for. The researchers wanted to determine whether the babies would reach for the helper puppet more than for the hinderer puppet.

    As part of the show, a green puppet and a yellow puppet served as the helper and hinderer. For each baby, a coin was tossed to determine which color would serve which role. Which of the following is the most important reason for the random assignment of color to role in the study?

    (A) Slamming the lid might cause wear on the hinderer puppet after 60 shows. The random assignment of color to role permits more even wear between the helper and the hinderer.

    (B) The puppeteer might grow tired of doing the same show with the same puppet colors. The random assignment of color to role keeps the show fresh for each performance.

    (C) If the same role is played by the same color puppet, the babies might show a preference for the color instead of a preference for the role.

    (D) The random assignment of color to role allows the researchers to determine if one color is better than another in teaching babies right from wrong.

    (E) Boys and girls might prefer different colors. The random assignment of color to role ensures that the show is equally accessible to boys and girls.

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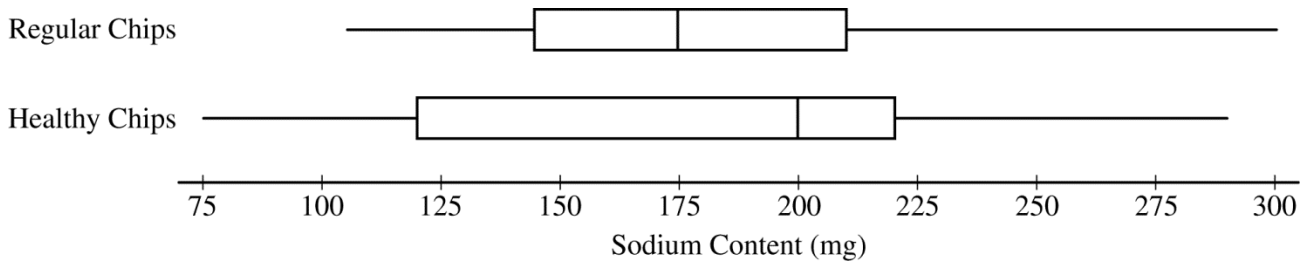
19. Nutritionists examined the sodium content of different brands of potato chips. Each brand was classified as either healthy or regular based on how the chips were marketed to the public. The sodium contents, in milligrams (mg) per serving, of the chips are summarized in the boxplots below.



Based on the boxplots, which statement gives a correct comparison between the two classifications of the sodium content of the chips?

(A) The number of brands classified as healthy is greater than the number of brands classified as regular.

(B) The interquartile range (IQR) of the brands classified as healthy is greater than the IQR of the brands classified as regular.

(C) The range of the brands classified as healthy is less than the range of the brands classified as regular.

(D) The median of the brands classified as healthy is more than twice the median of the brands classified as regular.

(E) The brand with the least sodium content and the brand with the greatest sodium content are both classified as healthy.

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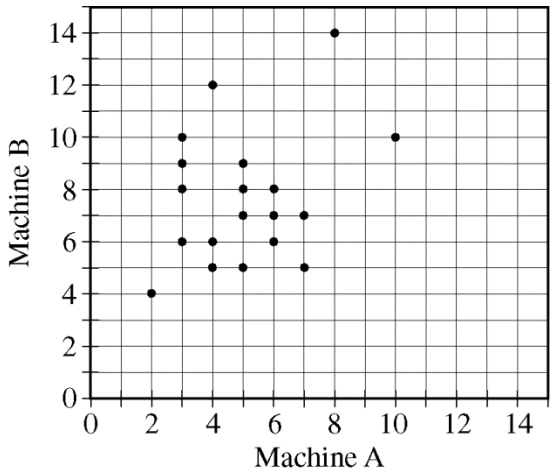
20. A factory has two machines, A and B, making the same part for refrigerators. The number of defective parts produced by each machine during the first hour of operation was recorded on 19 randomly selected days. The scatterplot below shows the number of defective parts produced by each machine on the selected days.



Which statement gives the best comparison between the number of defective parts produced by the machines during the first hour of operation on the 19 days?

(A) Machine A always produced the same number of defective parts as machine B.

(B) Machine A always produced fewer defective parts than machine B.

(C) Machine A always produced more defective parts than machine B.

(D) Machine A usually, but not always, produced fewer defective parts than machine B.

(E) Machine A usually, but not always, produced more defective parts than machine B.

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Item 21 was not scored.

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22. The faces of a four-sided fair die are numbered 1 through 4, respectively. For a certain game, the die is tossed and the number that lands facedown is recorded. The table below summarizes the points a player earns for the number that lands facedown.

Number landing facedown	1	2	3	4
Points	0	1	0	2

Consider two independent tosses of the die. Let the random variable S represent the sum of the points earned from the two tosses. Which table represents the probability distribution of S ?

(A)

S	0	1	2
Probability	0.5	0.25	0.25

(B)

S	0	2	4
Probability	0.5	0.25	0.25

(C)

S	0	2	4
Probability	0.25	0.5	0.25

(D)

S	0	1	2	3	4
Probability	0.25	0.25	0.3125	0.125	0.0625

(E)

S	0	1	2	3	4
Probability	0.0625	0.25	0.375	0.25	0.0625

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23. A botanist collected one leaf at random from each of 10 randomly selected mature maple trees of the same species. The mean and the standard deviation of the surface areas for the 10 leaves in the sample were computed. Assume the distribution of surface areas of maple leaves is normal. What is the appropriate method for constructing a one-sample confidence interval to estimate the population mean surface area of the species of maple leaves, and why is the method appropriate?

(A) The t-interval is appropriate, because the population standard deviation is not known.

(B) The t-interval is appropriate, because the t-interval is narrower than the z-interval.

(C) The z-interval is appropriate, because the z-interval is narrower than the t-interval.

(D) The z-interval is appropriate, because the central limit theorem applies.

(E) The z-interval is appropriate, because the sample standard deviation is known.

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24. A state educational agency was concerned that the salaries of public school teachers in one region of the state, region A, were higher than the salaries in another region of the state, region B. The agency took two independent random samples of salaries of public school teachers, one from region A and one from region B. The data are summarized in the table below.

	Region A	Region B
Mean salary	\$62,583	\$60,117
Standard deviation	\$6,274	\$9,319
Number of salaries	117	78

Assuming all conditions for inference are met, do the data provide convincing statistical evidence that the salaries of public school teachers in region A are, on average, greater than the salaries of public school teachers in region B?

(A) Yes, there is evidence at the significance level of $\alpha = 0.001$.

(B) Yes, there is evidence at the significance level of $\alpha = 0.01$ but not at $\alpha = 0.001$.

(C) Yes, there is evidence at the significance level of $\alpha = 0.05$ but not at $\alpha = 0.01$.

(D) Yes, there is evidence at the significance level of $\alpha = 0.10$ but not at $\alpha = 0.05$.

(E) No, there is no evidence at the significance level of $\alpha = 0.10$.

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25. A florist wanted to investigate whether a new powder added to the water of cut flowers helps to keep the flowers fresh longer than just water alone. For a shipment of roses that was delivered to the store, the florist flipped a coin before placing each rose in its own individual container with water. If the coin landed heads up, the rose was placed in water with the new powder; otherwise, the rose was placed in water alone. Which of the following is the best description of the method used by the florist?

(A) A census, because all roses are assigned to a container
(B) An experiment with a completely randomized design
(C) An experiment with a blocked design, with blocking by type of water
(D) An experiment with a matched-pairs design
(E) An observational study

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26. A commercial for a breakfast cereal is shown during a certain television program. The manufacturer of the cereal wants to estimate the percent of television viewers who watch the program. The manufacturer wants the estimate to have a margin of error of at most 0.02 at a level of 95 percent confidence. Of the following, which is the smallest sample size that will satisfy the manufacturer's requirements?

(A) 40

(B) 50

(C) 100

(D) 1,700

(E) 2,500

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27. A contestant's final winnings on a game show are determined by a random selection of a base amount and a possible multiplier. For the base amount, the contestant randomly selects one of four cards, where two cards are marked $1,000, one card is marked $2,000, and one card is marked $5,000. After choosing the card, the contestant randomly selects one of five chips, where three chips are red and two chips are white. If the selected chip is red, the contestant's final winnings are twice the value of the base amount. If the selected chip is white, the contestant's final winnings are the value of the base amount. What is the probability that a contestant's final winnings are exactly $2,000 ?

(A) 0.100
(B) 0.200
(C) 0.250
(D) 0.325
(E) 0.400

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28. Meteorologists are interested in the relationship between minimum pressure and maximum wind speed of hurricanes. The minimum pressure, in millibars, and maximum wind speed, in knots, were collected for a random sample of 100 hurricanes from the year 1995 to the year 2012. A regression analysis of maximum wind speed on minimum pressure produced a 95 percent confidence interval of $(-1.42, -1.20)$ for the slope of the least-squares regression line. Which statement is a correct interpretation of the interval?

(A) The probability is 0.95 that wind speed will decrease, on average, between 1.20 knots and 1.42 knots for each millibar increase in minimum pressure.

(B) The probability is 0.95 that a different sample of 100 hurricanes will result in an increase, on average, of wind speed between 1.20 knots and 1.42 knots for each millibar increase in minimum pressure.

(C) We can be 95% confident that wind speed decreases, on average, between 1.20 knots and 1.42 knots for each millibar increase in minimum pressure.

(D) We can be 95% confident that wind speed increases, on average, between 1.20 knots and 1.42 knots for each millibar increase in minimum pressure.

(E) We can be 95% confident that, for any sample of hurricanes, the wind speed will decrease, on average, between 1.20 knots and 1.42 knots for each millibar increase in minimum pressure.

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29. Some contact lens wearers report problems with dryness in their eyes. A study was conducted to evaluate the effectiveness of a new eye-drop solution to relieve dryness for contact lens wearers. Twenty-five volunteers who wore contact lenses agreed to use the new solution for one month. At the end of the month, 36 percent of the volunteers reported that the new solution was effective in relieving dryness. The company that produced the new eye-drop solution concluded that using the new solution is more effective in relieving dryness than using no solution. Which of the following best explains why the study does not support such a conclusion?

(A) The sample size was too small.

(B) The study had no control group.

(C) The participants were volunteers.

(D) The participants self-reported the frequency with which they used the new solution.

(E) The participants self-reported the effectiveness of the new solution.

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30. The management team of a company with 10,000 employees is considering installing charging stations for electric cars in the company parking lots. In a random sample of 500 employees, 15 reported owning an electric car. Which of the following is a 99 percent confidence interval for the proportion of all employees at the company who own an electric car?

(A) $0.03 \pm 2.326\sqrt{\frac{(0.03)(0.97)}{500}}$

(B) $0.15 \pm 2.326\sqrt{\frac{(0.15)(0.85)}{500}}$

(C) $0.03 \pm 2.576\sqrt{\frac{(0.03)(0.97)}{500}}$

(D) $0.15 \pm 2.576\sqrt{\frac{(0.15)(0.85)}{500}}$

(E) $0.03 \pm 2.576\sqrt{\frac{(0.03)(0.97)}{500} + \frac{(0.03)(0.97)}{10,000}}$

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31. A test of the hypotheses $H_0 : \mu = 0$ versus $H_a : \mu > 0$ was conducted using a sample of size 7. The test statistic was $t = 1.935$. Which of the following is closest to the *p*-value of the test?

(A) 0.0125

(B) 0.0265

(C) 0.0471

(D) 0.0506

(E) 0.1012

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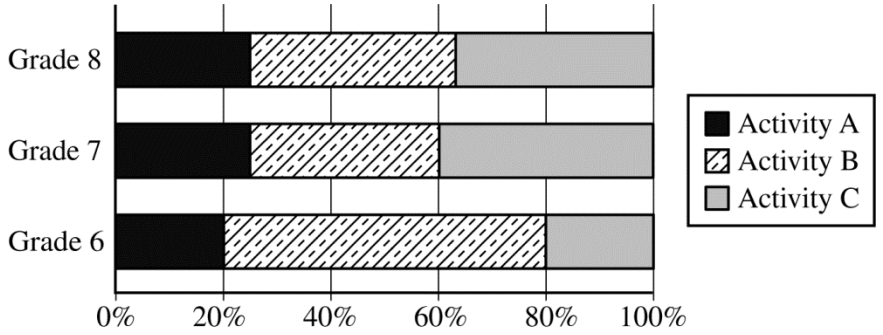
32. As part of a community service program, students in three middle school grades (grade 6, grade 7, grade 8) each chose to participate in one of three school-sponsored volunteer activities. The graph below shows the distribution for each class for the three activities.



Based on the graph, which statement must be true?

(A) Of all the students who chose activity B, the greatest number of students were in grade 6.

(B) Grade 7 and grade 8 had the same number of students who did not choose activity A.

(C) The grade with the greatest percentage of students who chose activity C was grade 8.

(D) For students in grade 7, the number who chose activity C was greater than the number who chose activity B.

(E) For students in grade 8, the number who chose activity A was greater than the number who chose activity B.

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33. At a large airport, data were recorded for one month on how many baggage items were unloaded from each flight upon arrival as well as the time required to deliver all the baggage items on the flight to the baggage claim area. A scatterplot of the two variables indicated a strong, positive linear association between the variables. Which of the following statements is a correct interpretation of the word "strong" in the description of the association?

(A) A least-squares model predicts that the more baggage items that are unloaded from a flight, the greater the time required to deliver the items to the baggage claim area.

(B) The actual time required to deliver all the items to the baggage claim area based on the number of items unloaded will be very close to the time predicted by a least-squares model.

(C) The time required to deliver an item to the baggage claim area is relatively constant, regardless of the number of baggage items unloaded from a flight.

(D) The variability in the time required to deliver all items to the baggage claim area is about the same for all flights, regardless of the number of items unloaded from a flight.

(E) The time required to unload baggage items from a flight is related to the time required to deliver the items to the baggage claim area.

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34. A group of men and women were surveyed to investigate the association between gender and the number of friends the person has on a social media Web site. Results are shown in the table below.

	Number of Friends				
	0 to 50	51 to 100	101 to 150	151 to 200	201 or more
Men	17	82	73	56	42
Women	45	73	98	87	75

Which of the following procedures is the most appropriate for investigating whether an association exists between gender and the number of friends a person has on a social media Web site?

(A) A matched-pairs *t*-test for a mean difference

(B) A two-sample *t*-test for the difference between means

(C) A *t*-test for the slope of the regression line

(D) A chi-square goodness-of-fit test

(E) A chi-square test of independence

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35. Carly commutes to work, and her commute time is dependent on the weather. When the weather is good, the distribution of her commute times is approximately normal with mean 20 minutes and standard deviation 2 minutes. When the weather is not good, the distribution of her commute times is approximately normal with mean 30 minutes and standard deviation 4 minutes. Suppose the probability that the weather will be good tomorrow is 0.9. Which of the following is closest to the probability that Carly's commute time tomorrow will be greater than 25 minutes?

(A) 0.0056

(B) 0.0894

(C) 0.0950

(D) 0.8055

(E) 0.9006

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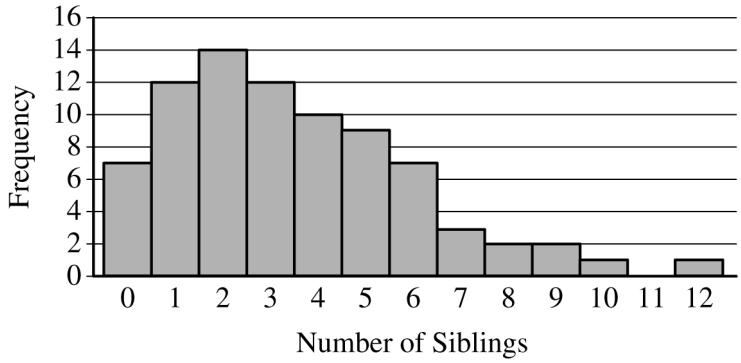
36. The number of siblings was recorded for each student of a group of 80 students. Some summary statistics and a histogram displaying the results are shown below.

Mean	Standard Deviation	Q1	Q3
3.5	2.535	2	5



An outlier is often defined as a number that is more than 1.5 times the interquartile range below the first quartile or above the third quartile. Using the definition of an outlier and the given information, which of the following can be concluded?

(A) The median is greater than the mean, and the distribution has no outliers.

(B) The median is greater than the mean, and the distribution has only one outlier.

(C) The median is greater than the mean, and the distribution has two outliers.

(D) The median is less than the mean, and the distribution has only one outlier.

(E) The median is less than the mean, and the distribution has two outliers.

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37. In the states of Florida and Colorado, veterinarians investigating obesity in dogs obtained random samples of pet medical records and recorded the weights of the dogs in the samples. A test was conducted of $H_0 : p_1 = p_2$ versus $H_a : p_1 \neq p_2$, where p_1 represents the proportion of all overweight dogs in Florida and p_2 represents the proportion of all overweight dogs in Colorado. The resulting test statistic for a two-sample z-test for a difference between proportions was 1.85. At the significance level $\alpha = 0.05$, which of the following is a correct conclusion?

(A) There is not sufficient statistical evidence to conclude that the proportion of all overweight dogs in Florida is different from the proportion of all overweight dogs in Colorado because the p-value is greater than 0.05.

(B) There is not sufficient statistical evidence to conclude that the proportion of all overweight dogs in Florida is different from the proportion of all overweight dogs in Colorado because the z-test statistic is greater than 0.05.

(C) There is sufficient statistical evidence to conclude that the proportion of all overweight dogs in Florida is different from the proportion of all overweight dogs in Colorado because the p-value is greater than 0.05.

(D) There is sufficient statistical evidence to conclude that the proportion of all overweight dogs in Florida is different from the proportion of all overweight dogs in Colorado because the p-value is less than 0.05.

(E) There is sufficient statistical evidence to conclude that the proportion of all overweight dogs in Florida is greater than the proportion of all overweight dogs in Colorado because the z-test statistic is positive.

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38. A newspaper editor wants to investigate whether residents of the city support a proposal to build a new high school football stadium. The editor hires a polling firm to conduct a survey and requests that a sample of 500 residents be selected using a stratified sampling design based on voting districts within the city. Which of the following methods will achieve the desired sampling design?

(A) Send a survey to all city residents and use the first 500 returned surveys for the sample.

(B) Select a random sample from each voting district based on the proportion of city residents in the district so that a total of 500 is obtained.

(C) Select one voting district at random, and then select a random sample of 500 from the selected voting district.

(D) Alphabetize a list of all city residents, and then select the first 500 residents on the list, classifying those selected by voting district.

(E) Select the first 500 city residents who attend the next high school football game.

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39. A simulation was conducted using 10 fair six-sided dice, where the faces were numbered 1 through 6, respectively. All 10 dice were rolled, and the average of the 10 numbers appearing faceup was recorded. The process was repeated 20 times. Which of the following best describes the distribution being simulated?

(A) A sampling distribution of a sample mean with $n = 10$, $\mu_{\bar{x}} = 3.5$, and $\sigma_{\bar{x}} \approx 0.54$

(B) A sampling distribution of a sample mean with $n = 10$, $\mu_{\bar{x}} = 3.5$, and $\sigma_{\bar{x}} \approx 1.71$

(C) A sampling distribution of a sample mean with $n = 20$, $\mu_{\bar{x}} = 3.5$, and $\sigma_{\bar{x}} \approx 0.38$

(D) A sampling distribution of a sample proportion with $n = 10$, $\mu_{\hat{p}} = \frac{1}{6}$, and $\sigma_{\hat{p}} \approx 0.118$

(E) A sampling distribution of a sample proportion with $n = 20$, $\mu_{\hat{p}} = \frac{1}{6}$, and $\sigma_{\hat{p}} \approx 0.083$

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40. The SC Electric Company has bid on two electrical wiring jobs. The owner of the company believes that

- the probability of being awarded the first job (event A) is 0.75;
- the probability of being awarded the second job (event B) is 0.5; and
- the probability of being awarded both jobs (event (A and B)) is 0.375.

If the owner's beliefs are correct, which of the following statements must be true concerning event A and event B ?

(A) Event A and event B are mutually exclusive and are independent.

(B) Event A and event B are mutually exclusive and are not independent.

(C) Event A and event B are not mutually exclusive and are independent.

(D) Event A and event B are not mutually exclusive and are not independent.

(E) Event A and event B are not mutually exclusive, and independence cannot be determined with the information given.

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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.

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.

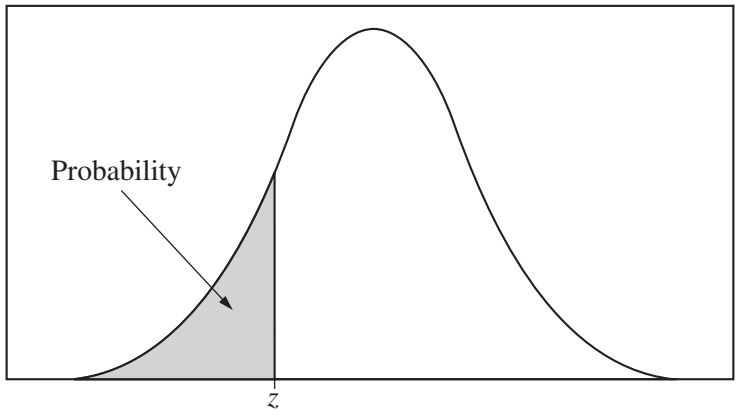

Table A Standard normal probabilities

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.

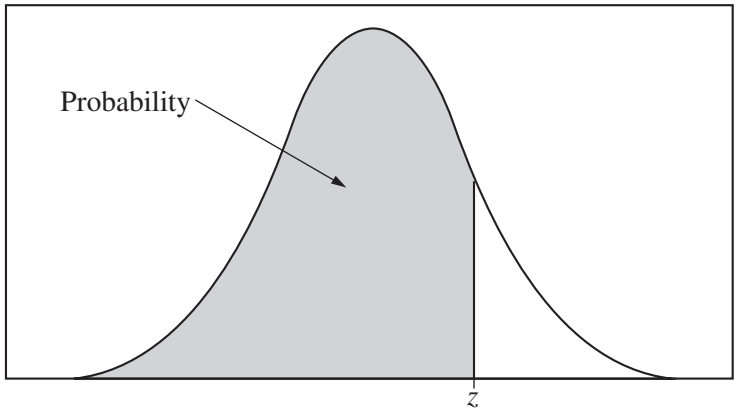

Table A (*Continued*)

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^*.

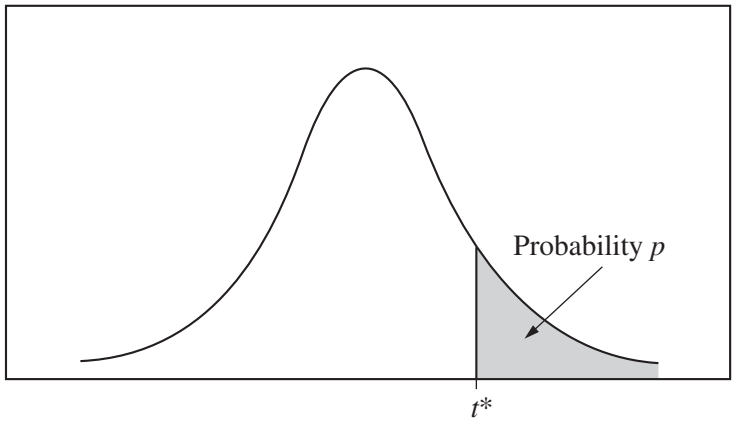

Table B ***t* distribution critical values**

	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.

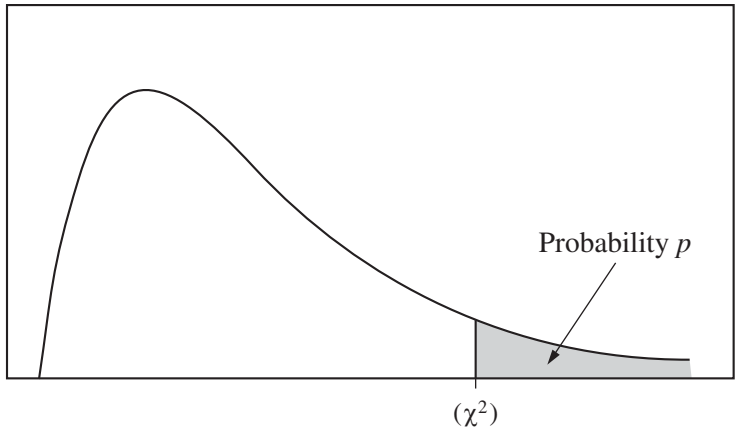

Table C χ^2 critical values

	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

AP® Statistics Exam

SECTION II: Free Response

2016

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

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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
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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.

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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.

Form I
Form Code 4MBP4-S

90

Formulas begin on page 3.
Questions begin on page 6.
Tables begin on page 22.

Formulas

(I) Descriptive Statistics

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

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

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

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

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

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

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

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

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

(II) Probability

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

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

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

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

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

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

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

(III) Inferential Statistics

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

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

Single-Sample

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

Two-Sample

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

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

STATISTICS

SECTION II

Part A

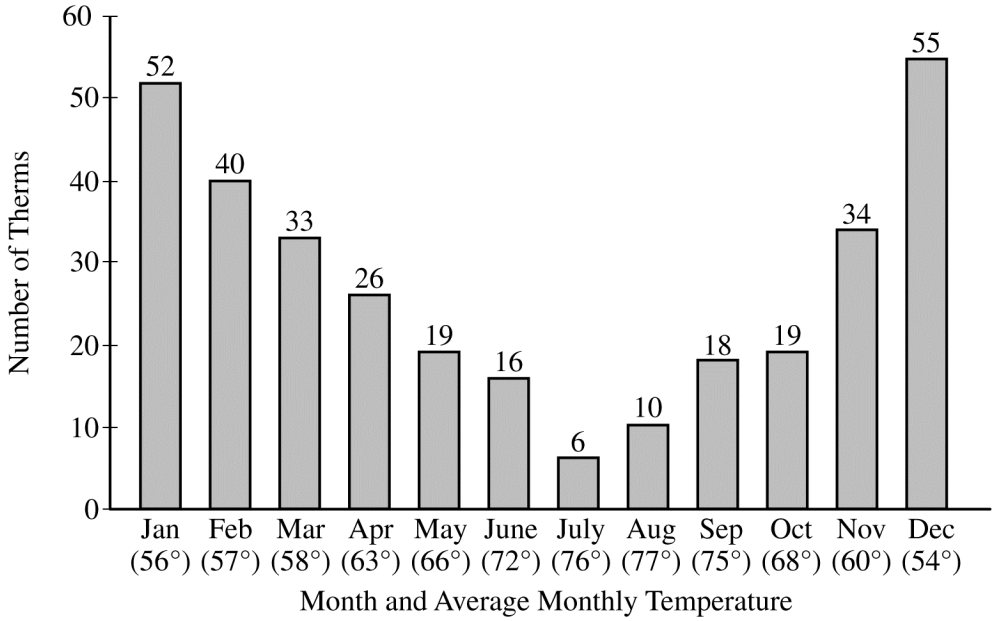
Questions 1-5

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. Natural gas is used in some households to heat the home, to heat the water, and to cook. A utility company sent the following bar chart to a household to show the amount of natural gas, measured in therms (a unit of heat energy), that the household used last year. The chart shows the number of therms and the average monthly temperature, in degrees Fahrenheit, for each month of the year.



(a) Describe how the number of therms used each month changed over the year.

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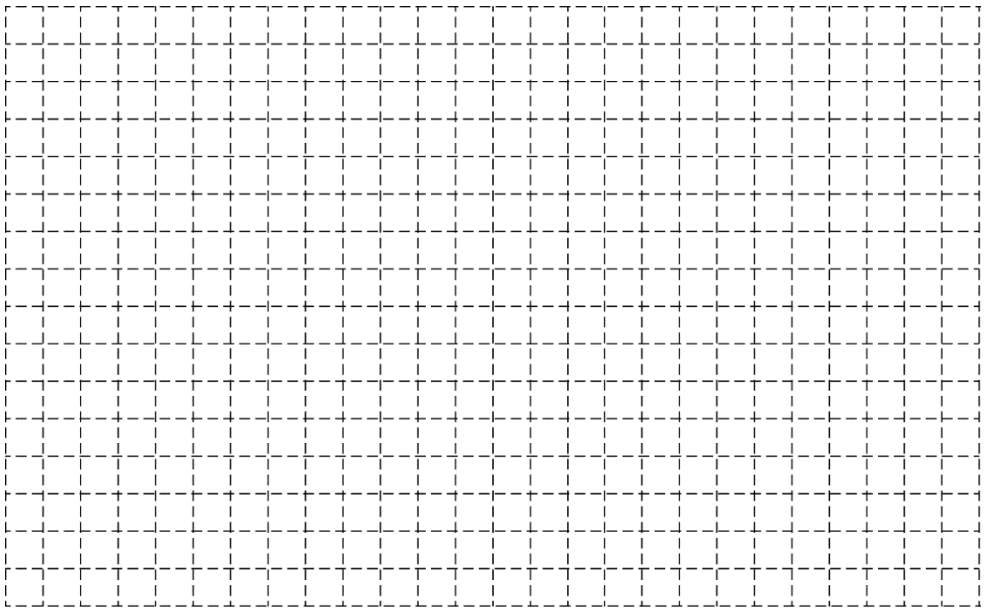
(b) Construct an appropriate graph that shows the relationship between the number of therms used and the average monthly temperature.



(c) Describe what your graph in part (b) reveals about the relationship between the number of therms used and the average monthly temperature that is not revealed on the bar chart sent by the utility company.

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2. Swedish researchers investigated the relationship between chocolate consumption and stroke. The researchers gave a questionnaire about eating habits to a randomly selected sample of Swedish men. Based on the responses to the questionnaire, the men were classified into two groups. Group A consisted of the 9,250 men who ate the most chocolate per week, and group B consisted of the 9,250 men who ate the least chocolate per week. The researchers tracked the men's health for ten years. During that time, there were 458 cases of stroke among the men in group A and 543 cases of stroke among the men in group B.

   (a) Do the data provide convincing statistical evidence that Swedish men who would be classified into group A have a lower probability of stroke than Swedish men who would be classified into group B?

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If you need more room for your work in part (a), use the space below.

(b) A report in a newspaper concluded that Swedish men can reduce their probability of stroke by eating more chocolate. Based on the description of the investigation, was the conclusion appropriate? Justify your answer.

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3. A large retail company has 500 stores in the United States and 300 stores in Europe. The average number of employees per store is 200, for a total of 100,000 employees in the United States and 60,000 employees in Europe. The company is considering offering employees one of two new benefits—one additional day of paid vacation per year or a small increase in pay. A survey will be given to a sample of employees to investigate which benefit is preferred and whether there is a difference in preference between employees in the United States and employees in Europe.

   Two sampling methods have been proposed.

   Sampling method 1: The company will randomly select 8 stores from its 800 stores. All employees at the 8 selected stores will be asked which benefit they prefer.

   Sampling method 2: The company will randomly select 1,000 employees from a list of all employees at the United States stores and 600 employees from a list of all employees at the European stores. All 1,600 selected employees will be asked which benefit they prefer.

   (a) One of the two methods results in a stratified sample of employees and the other results in a cluster sample of employees.

      (i) Identify the sampling method that results in a stratified sample of employees, and identify the strata.

      Sampling method number: Strata:

      (ii) Identify the sampling method that results in a cluster sample of employees, and identify the clusters.

      Sampling method number: Clusters:

   (b) Give one statistical advantage and one statistical disadvantage of using sampling method 1.

      Advantage:

      Disadvantage:

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(c) Explain a statistical advantage of using sampling method 2 rather than using a simple random sample.

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4. In ecology, a measure of diversity of a species in a certain population is called the diversity index. The diversity index D is defined as the probability that any two organisms selected at random from the population will be from different species.

   (a) If every organism in a population is from the same species, what is the value of the diversity index D ? Explain.

   (b) Consider a large population of turtles in which 30 percent of the population are snapping turtles and 70 percent of the population are box turtles. What is the value of the diversity index D for the population?

   (c) Suppose a large population of turtles consists only of two species, snapping turtle and box turtle, but the percentages of the species in the population are not known. What is the maximum possible value of the diversity index D for the population? Justify your answer.

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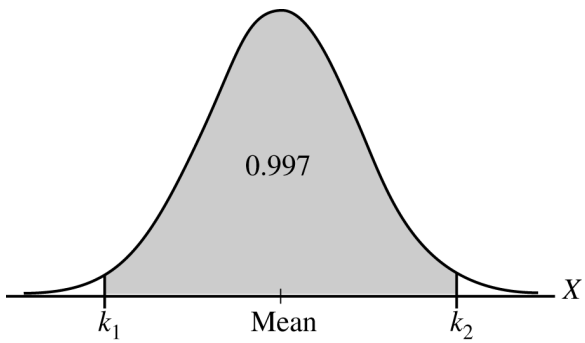
5. A city council is considering funding a proposal to create a new city park. The council members will fund the proposal if they conclude that more than 60 percent of the city residents support the proposal. A survey of 2,000 randomly selected city residents will be conducted to investigate the level of support for the proposal. Let X represent the number of city residents in the sample who support the proposal. Assume that X is a binomial random variable.

   (a) Determine the mean and the standard deviation of the random variable X, assuming that 60 percent of city residents support the proposal.

The figure below shows a normal distribution that can be used to approximate the binomial probability distribution of X. The shaded region is bounded by k_1 and k_2 on the figure and represents the middle 0.997 of the area under the curve.



   (b) Assume that 60 percent of the city residents support the proposal. Use a normal approximation and the mean and standard deviation from part (a) to determine the values of k_1 and k_2.

   $k_1 =$

   $k_2 =$

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(c) The survey was conducted, and 1,293 of the 2,000 city residents surveyed supported the proposal. Do your answers in part (b) and the survey results support the funding of the proposal? Justify your answer.

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STATISTICS

SECTION II

Part B

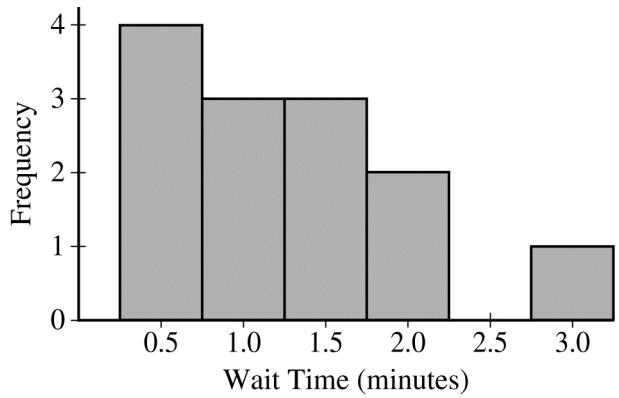
Question 6

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. Phone callers to a bank's customer service center must wait until a service representative is available to answer the phone call. The bank manager is interested in estimating the mean customer wait time. Thirteen calls were selected at random. A histogram of the 13 wait times, in minutes, is shown below.



(a) Based on the histogram, explain why it might not be appropriate to use a one-sample *t*-interval to estimate the mean wait time for all customers.

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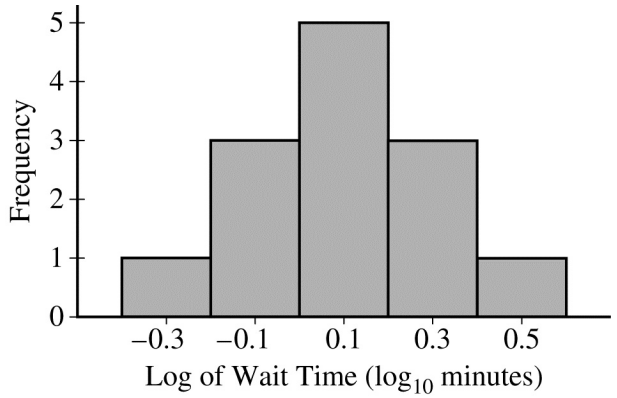
A logarithmic transformation is often used to transform data such as wait times. Let x represent a customer's wait time. The log transformation of the customer's wait time is given by $\log_{10} x$. The table below shows the original 13 wait times, the respective log-transformed wait times, and the corresponding means, medians, and standard deviations.

	Wait Time, x	$\log_{10} x$
	0.40	−0.3979
	0.66	−0.1805
	0.71	−0.1487
	0.71	−0.1487
	1.10	0.0414
	1.16	0.0645
	1.20	0.0792
	1.29	0.1106
	1.29	0.1106
	1.70	0.2304
	1.90	0.2788
	2.15	0.3324
	2.82	0.4502
Mean	1.31	0.0632
Median	1.20	0.0792
Standard deviation	0.679	0.235

A histogram of the 13 log-transformed data values is shown below.



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The summary statistics for x and $\log_{10} x$ are repeated below.

	Wait Time, x	$\log_{10} x$
Mean	1.31	0.0632
Median	1.20	0.0792
Standard deviation	0.679	0.235

(b) Based on the histogram, the conditions for inference have been met for the log-transformed data. Construct and interpret a 95 percent confidence interval for the population mean μ of the log of the wait times.

(c) The mean of the log-transformed data is 0.0632 $\log_{10}$ minutes, which can be converted back to 1.157 minutes by calculating $10^{0.0632}$. Convert the endpoints of your interval in part (b) back to minutes and write the resulting interval.

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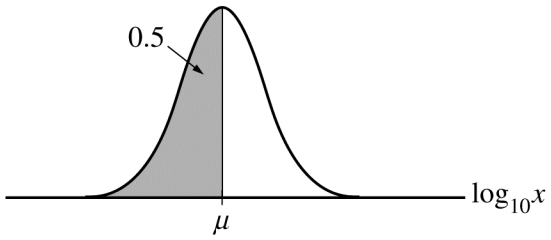
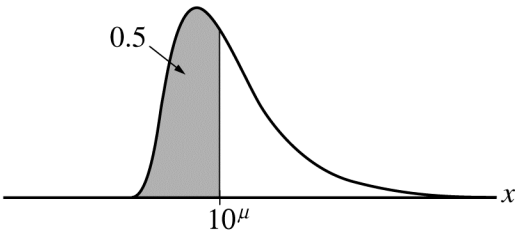
Graph 1 below shows a population distribution of the log of wait times, in $\log_{10}$ minutes, which is normal with mean μ. Graph 2 shows the result of converting the population distribution in Graph 1 back to the population distribution of wait times, in minutes. The lower 50 percent of the distribution is shaded in each graph.

Graph 1
Population Distribution of Log of Wait Time



Graph 2
Population Distribution of Wait Time



(d) Consider the parameter 10^{μ} in Graph 2.

(i) How does the parameter 10^{μ} compare with the median of the population distribution of wait times?

(ii) How does the parameter 10^{μ} compare with the mean of the population distribution of wait times?

(e) Write an interpretation of the interval you constructed in part (c).

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GO ON TO THE NEXT PAGE.

STOP

END OF EXAM

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 ON THE COVER.**
- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMS YOU HAVE TAKEN THIS YEAR.**

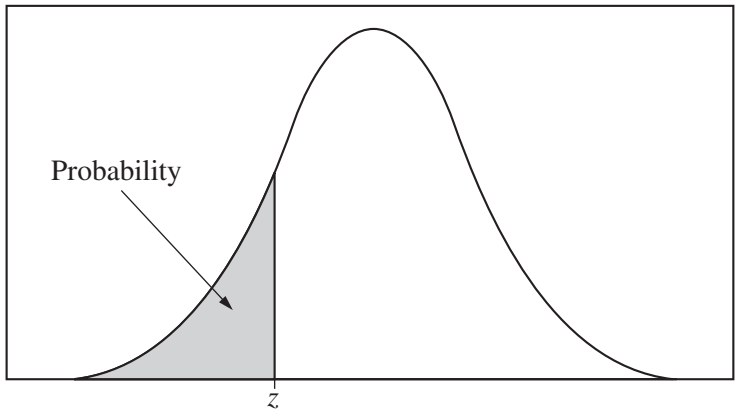

Table entry for z is the probability lying below z.

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

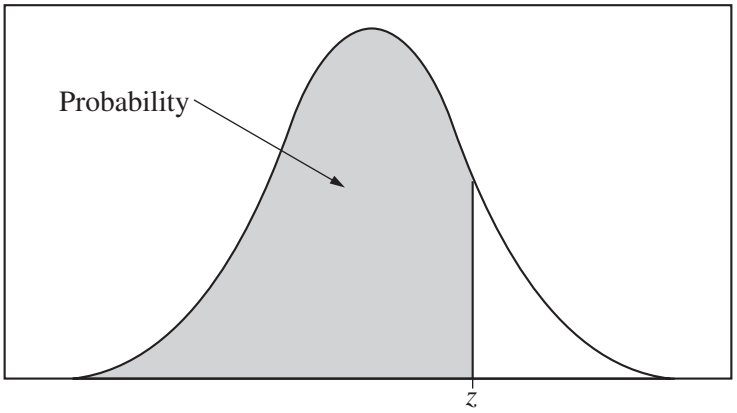

Table entry for z is the probability lying below z.

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^*.

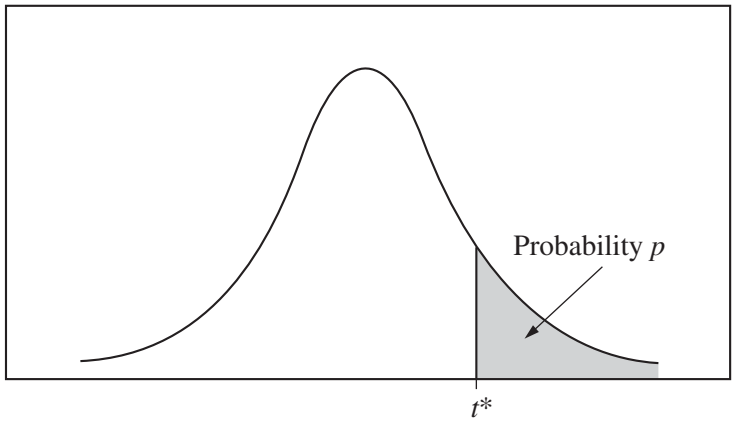

Table B ***t* distribution critical values**

	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.

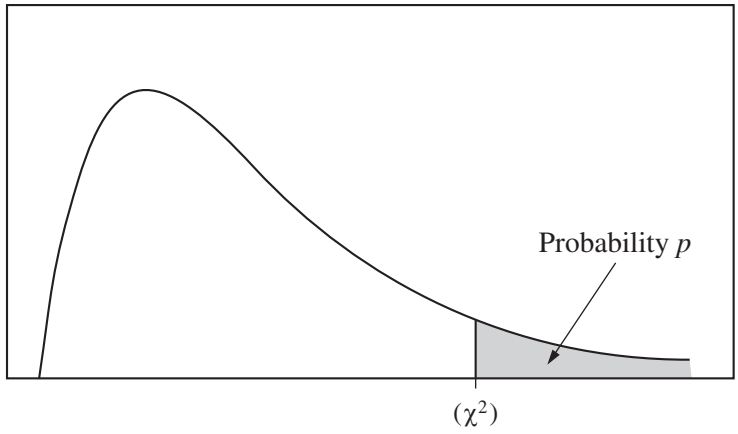

Table C χ^2 critical values

	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