From the 2018 Administration

AP CollegeBoard

AP Statistics

Practice Exam

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AP® Statistics Exam

SECTION I: Multiple Choice

2018

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

At a Glance

Total Time
1 hour and 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 4OBP4-S

90

Formulas

(I) Descriptive Statistics

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

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

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

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

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

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

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

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

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

(II) Probability

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

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

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

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

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 i is the mean of a random sample of size n from an infinite population with mean u and standard deviation o, 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

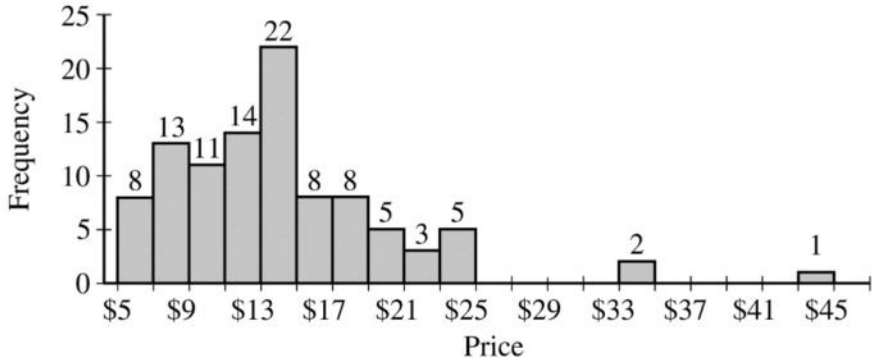
Time—1 hour and 30 minutes

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 histogram shown summarizes the responses of 100 people when asked, "What was the price of the last meal you purchased?"



Based on the histogram, which of the following could be the interquartile range of the prices?

(A) $40

(B) $21

(C) $10

(D) $5

(E) $3

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2. Suppose a certain scale is not calibrated correctly, and as a result, the mass of any object is displayed as 0.75 kilogram less than its actual mass. What is the correlation between the actual masses of a set of objects and the respective masses of the same set of objects displayed by the scale?

(A) -1
(B) -0.75
(C) 0
(D) 0.75
(E) 1

---

3. A veterinarian collected data on the weights of 1,000 cats and dogs treated at a veterinary clinic. The weight of each animal was classified as either healthy, underweight, or overweight. The data are summarized in the table.

	Healthy	Underweight	Overweight	Total
Cat	386	54	105	545
Dog	299	83	73	455
Total	685	137	178	1,000

Based on the data in the table, which of the following is the most appropriate type of graph to visually show whether a relationship exists between the type of animal and the weight classification?

(A) Back-to-back stemplots
(B) Scatterplot
(C) Side-by-side boxplots
(D) Segmented bar chart
(E) Dotplot

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4. A program exists to encourage more middle school students to major in math and science when they go to college. The organizers of the program want to estimate the proportion of students who, after completing the program, go on to major in math or science in college. The organizers will select a sample of students from a list of all students who completed the program. Which of the following sampling methods describes a stratified random sample?

(A) Select all female students on the list.

(B) Randomly select 50 students on the list.

(C) Randomize the names on the list and then select every tenth student on the randomized list.

(D) Randomly select 25 names from the female students on the list and randomly select 25 names from the male students on the list.

(E) Randomly select 50 students on the list who are attending college.

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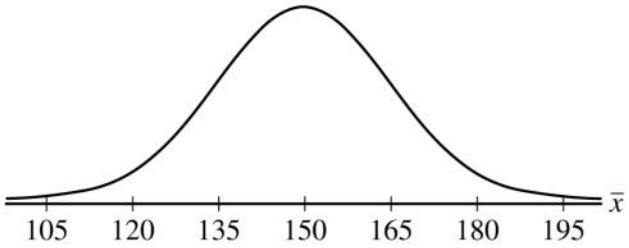
5. The normal curve shown represents the sampling distribution of a sample mean for sample size $n = 25$, selected at random from a population with standard deviation ox.



Sampling Distribution of $\bar{x}$

Which of the following is the best estimate of the standard deviation of the population, ox ?

(A) 3

(B) 6

(C) 15

(D) 30

(E) 75

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6. Two random samples, A and B, were selected from the same population to estimate the population mean. For each sample, the mean, standard deviation, and margin of error for a 95 percent confidence interval for the population mean are shown in the table.

	Mean	Standard Deviation	Margin of Error
Sample A	45	6.45	1.02
Sample B	43	7.84	0.72

Which of the following could explain why the margin of error of sample A is greater than the margin of error of sample B?

(A) The sample size of A is greater than the sample size of B.

(B) The sample size of A is less than the sample size of B.

(C) The sample size of A is equal to the sample size of B.

(D) The mean of sample A is greater than the mean of sample B.

(E) The standard deviation of sample A is less than the standard deviation of sample B.

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7. Nyasha's financial literacy project involved comparing the annual sales of companies in Canada and companies in the United States that produce software. Using the ratio of 1 Canadian dollar to 0.75 United States dollar, she converted all annual sales from the Canadian companies into United States dollars. For which of the following will the value of the statistic for the annual sales in Canadian dollars be equal to the value of the corresponding statistic in United States dollars?

(A) The median annual sales

(B) The standard deviation of the annual sales

(C) The standardized score of the minimum annual sales

(D) The mean annual sales

(E) The interquartile range of the annual sales

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8. The manager of a restaurant tracks the types of dinners that customers order from the menu to ensure that the correct amount of food is ordered from the supplier each week. Data from customer orders last year suggest the following weekly distribution.

Type of Dinner	Beef	Chicken	Fish	Pork	Vegetarian
Proportion	0.18	0.41	0.15	0.20	0.06

The manager believes that there might be a change in the distribution from last year to this year. A random sample of 200 orders was taken from all customer orders placed last week. The following table shows the results of the sample.

Type of Dinner	Beef	Chicken	Fish	Pork	Vegetarian
Frequency	32	86	34	30	18

Assume each order is independent. For which type of dinner is the value of its contribution to the appropriate test statistic the greatest?

(A) Beef

(B) Chicken

(C) Fish

(D) Pork

(E) Vegetarian

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9. A company that makes fleece clothing uses fleece produced from two farms, Northern Farm and Western Farm. Let the random variable X represent the weight of fleece produced by a sheep from Northern Farm. The distribution of X has mean 14.1 pounds and standard deviation 1.3 pounds. Let the random variable Y represent the weight of fleece produced by a sheep from Western Farm. The distribution of Y has mean 6.7 pounds and standard deviation 0.5 pound. Assume X and Y are independent. Let W equal the total weight of fleece from 10 randomly selected sheep from Northern Farm and 15 randomly selected sheep from Western Farm. Which of the following is the standard deviation, in pounds, of W?

(A) $1.3 + 0.5$

(B) $\sqrt{1.3^2 + 0.5^2}$

(C) $\sqrt{10(1.3)^2 + 15(0.5)^2}$

(D) $\sqrt{10^2(1.3)^2 + 15^2(0.5)^2}$

(E) $\sqrt{\frac{1.3^2}{10} + \frac{0.5^2}{15}}$

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10. According to a report for veterinarians in the United States, 36.5 percent of households in the United States own dogs and 30.4 percent of households in the United States own cats. If one household in the United States is selected at random, what is the probability that the selected household will own a dog or a cat?

(A) 0.111

(B) 0.331

(C) 0.558

(D) 0.669

(E) Not enough information is given to determine the probability.

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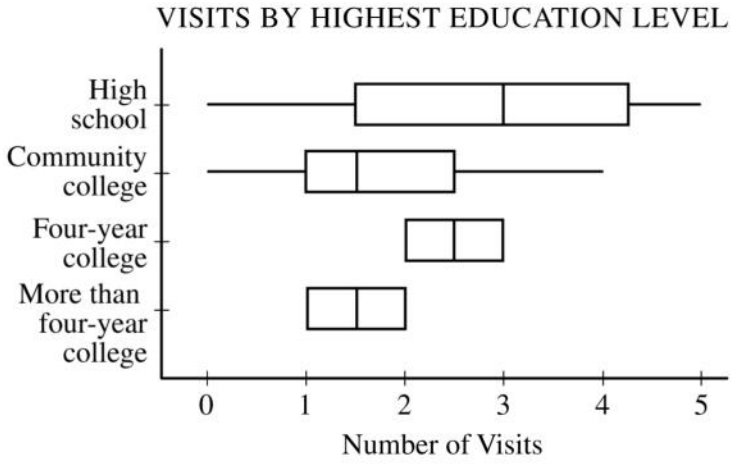
11. A sociologist collected data from a sample of people on their highest level of education and the number of times they visited any fast food restaurant during the previous week. The data are summarized in the boxplots.



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

(A) The number of people surveyed at the more than four-year college level is greater than the number of people surveyed at the high school level.

(B) The proportion of people surveyed from the first quartile to the third quartile at the four-year college level is less than the respective proportion at the community college level.

(C) The interquartile range (IQR) for the number of visits at the more than four-year college level is less than the IQR for the number of visits at the community college level.

(D) The maximum number of visits at the community college level is greater than the maximum number of visits at the high school level.

(E) The median number of visits at the four-year college level is greater than the median number of visits at the high school level.

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GO ON TO THE NEXT PAGE.

12. For a recent season in college football, the total number of rushing yards for that season is recorded for each running back. The mean number of rushing yards for the running backs that season is 790 yards. One running back had 1,637 rushing yards for the season, which is 2.42 standard deviations above the mean number of rushing yards. What is the standard deviation of the number of rushing yards for the running backs that season?

(A) 250 yards

(B) 300 yards

(C) 350 yards

(D) 400 yards

(E) 450 yards

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13. First-year students enrolled at a college were asked whether they play video games. The responses, classified by whether the students were enrolled in the school of sciences or the school of arts, are shown in the table.

	Play Video Games	Do Not Play Video Games	Total
Sciences	519	120	639
Arts	347	446	793
Total	866	566	1,432

Of all the students enrolled in the school of arts who responded, approximately what proportion responded that they play video games?

(A) 0.242

(B) 0.401

(C) 0.438

(D) 0.554

(E) 0.605

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14. A pharmaceutical company manufactures medicine to reduce pain caused by migraine headaches. The company is investigating whether a new medicine is more effective in reducing pain than the current medicine. A random sample of 500 participants who experience migraines was selected, and the participants were randomly assigned to one of two groups of equal size. The first group received the current medicine and the second group received the new medicine. When a participant experienced a migraine, he or she was instructed to take the medicine and, 15 minutes after taking the medicine, to rate the pain relief on a scale from 1 to 10, with 1 being no relief to 10 being complete relief. At the end of six months, the average pain relief for each participant was calculated. Which of the following is the best description of the study?

(A) An experiment using a completely randomized design

(B) An experiment using a matched-pairs design

(C) An observational study using a simple random sample

(D) An observational study using a cluster sample

(E) An observational study using a stratified sample

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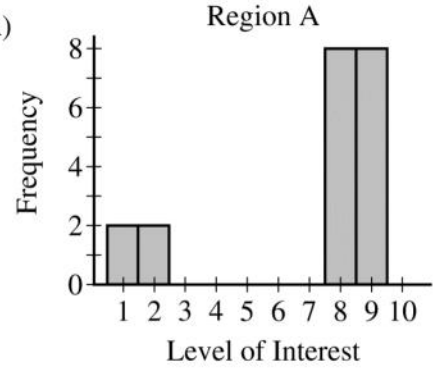
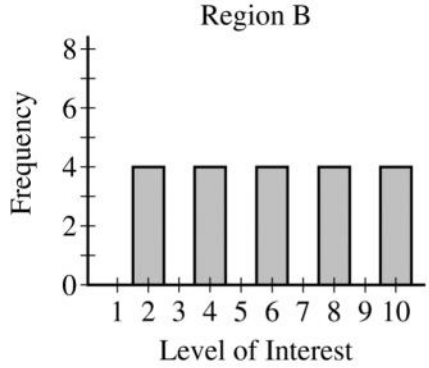
15. A marketing firm obtained random samples of 20 people in five regions of the country to investigate the level of interest in a new product. People in the sample were asked to rate their level of interest on a scale from 1 to 10, with 1 being the least amount of interest and 10 being the greatest. The histograms show the results for each region. The graph for which region displays data for level of interest with the least standard deviation?

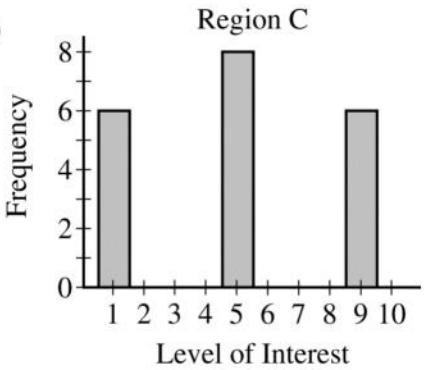
(A)



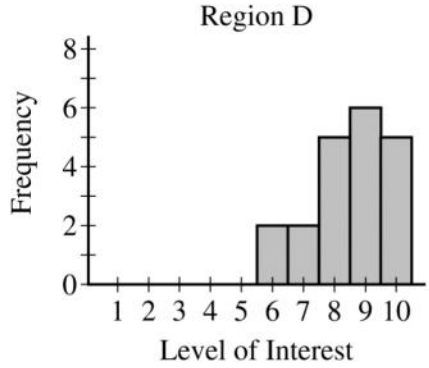
(B)



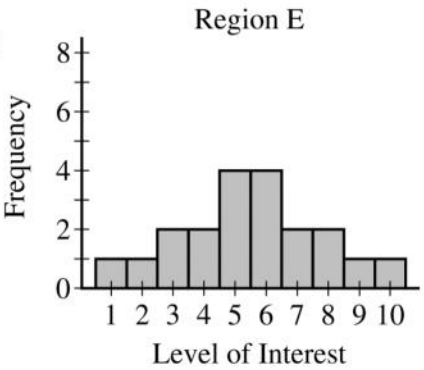
(C)



(D)



(E)



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GO ON TO THE NEXT PAGE.

16. The transportation department of a large city wants to estimate the proportion of residents who would use a system of aerial gondolas to commute to work. The gondolas would be part of the city's effort to relieve traffic congestion. The department asked a random sample of residents whether they would use the gondolas. The residents could respond with yes, no, or maybe. Which of the following is the best description of the method for data collection used by the department?

(A) A census

(B) A sample survey

(C) An experiment with a completely randomized design

(D) An experiment with a randomized block design

(E) An experiment with a matched-pairs design

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17. To obtain certification for a certain occupation, candidates take a proficiency exam. The exam consists of two sections, and neither section should be more difficult than the other. To investigate whether one section of the exam was more difficult than the other, a random sample of 50 candidates was selected. The candidates took the exam and their scores on each section were recorded. The table shows the summary statistics.

	Mean Percent Correct	Standard Deviation Percent Correct
First section	75	10
Second section	65	5
Difference	10	8

Which of the following is the test statistic for the appropriate test to determine if there is a significant mean difference between the percent correct on the two sections (first minus second) for all candidates similar to those in the investigation?

(A) $t = \dfrac{75 - 65}{\dfrac{8}{\sqrt{50}}}$

(B) $t = \dfrac{75 - 65}{\sqrt{\dfrac{10^2}{50} + \dfrac{5^2}{50}}}$

(C) $\chi^2 = \dfrac{(75 - 70)^2}{70} + \dfrac{(65 - 70)^2}{70}$

(D) $\chi^2 = \dfrac{(75 - 70)^2}{75} + \dfrac{(65 - 70)^2}{65}$

(E) $z = \dfrac{0.75 - 0.65}{\sqrt{0.7(1 - 0.7)\left(\dfrac{1}{50} + \dfrac{1}{50}\right)}}$

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GO ON TO THE NEXT PAGE.

18. New employees at a large corporation go through a training program during their first week of employment. The new employees take a written assessment at the completion of the program to determine how well prepared they are for their jobs. A score greater than the mean indicates a well-prepared employee. Assume the following distributions of new employee scores have the same mean score, the same maximum score, and the same minimum score. Which distribution has a shape that is most likely to represent the greatest percent of well-prepared employees?

(A) The distribution of scores is skewed to the right.

(B) The distribution of scores is skewed to the left.

(C) The distribution of scores is bimodal and symmetric.

(D) The distribution of scores is uniform.

(E) The distribution of scores is approximately normal.

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19. Based on his past record, Luke, an archer for a college archery team, has a probability of 0.90 of hitting the inner ring of the target with a shot of the arrow. Assume that in one practice Luke will attempt 5 shots of the arrow and that each shot is independent from the others. Let the random variable X represent the number of times he hits the inner ring of the target in 5 attempts. The probability distribution of X is given in the table.

X	0	1	2	3	4	5
$P(X)$	0.00001	0.00045	0.00810	0.07290	0.32805	0.59049

What is the probability that the number of times Luke will hit the inner ring of the target out of the 5 attempts is less than the mean of X ?

(A) 0.40951

(B) 0.50000

(C) 0.59049

(D) 0.91854

(E) 0.99144

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20. A medical center conducted a study to investigate cholesterol levels in people who have had heart attacks. A random sample of 16 people was obtained from the names of all patients of the medical center who had a heart attack in the previous year. Of the people in the sample, the mean cholesterol level was 264.70 milligrams per deciliter (mg/dL) with standard deviation 42.12 mg/dL. Assuming all conditions for inference were met, which of the following is a 90 percent confidence interval for the mean cholesterol level, in mg/dL, of all patients of the medical center who had a heart attack in the previous year?

(A) (242.26, 287.14)

(B) (244.06, 285.34)

(C) (246.24, 283.16)

(D) (247.38, 282.02)

(E) (260.09, 269.31)

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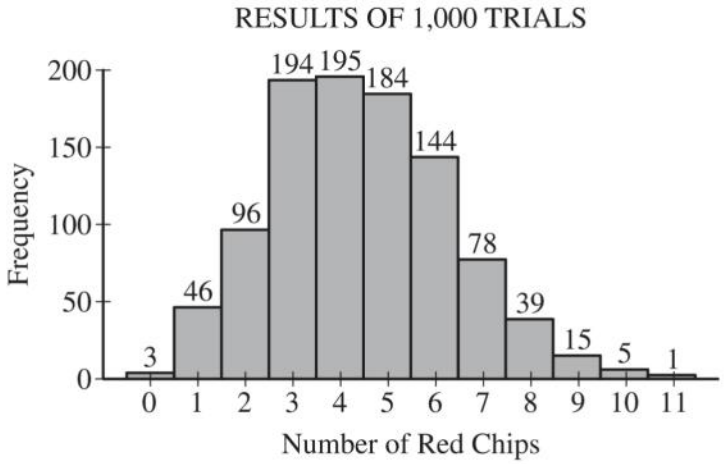
21. For a school fund-raiser, 600 raffle tickets were sold by students at the school, of which 88 were sold by one student, Audrey. Of the 600 tickets sold, 30 were randomly selected to receive prizes, and 7 of the 30 tickets selected were tickets sold by Audrey. To investigate how likely it was by chance alone that at least 7 of the 30 selected tickets could have been sold by Audrey, students in a statistics class ran a simulation. One trial of the simulation is described by the following steps.

Step 1: From 600 chips, assign 88 red and the rest blue.

Step 2: Select 30 chips at random without replacement.

Step 3: Record the number of red chips in the selection of 30.

The results of 1,000 trials of the simulation are shown in the histogram.



Based on the results of the simulation, is there convincing statistical evidence at the significance level of 0.05 that the event of Audrey selling at least 7 of the 30 selected tickets is unlikely to have occurred by chance alone?

(A) Yes, because the distribution of the trials in the simulation is skewed to the right.

(B) Yes, because the number in the histogram with the greatest frequency is 4, not 7.

(C) Yes, because 7 appears in the right tail of the distribution, indicating that it is more than 2 standard deviations away from the mean.

(D) No, because the simulation suggests that it is likely that Audrey could sell anywhere from 0 to 11 of the selected tickets.

(E) No, because the simulation suggests that Audrey selling at least 7 of 30 selected tickets would occur about 13.8% of the time.

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GO ON TO THE NEXT PAGE.

22. As part of a study on facility needs, the administrators of a university wanted to estimate the percent of students who use the exercise facilities on a regular basis. From the 34,000 students who attend the university, a random sample of 370 male students and 400 female students was selected. Of the 770 students selected, 493 students indicated that they use the exercise facilities on a regular basis. What are the population and the sample of the study?

(A) The population is the 770 students who were selected, and the sample is the 493 students who indicated that they use the exercise facilities on a regular basis.

(B) The population is the 770 students who were selected, and the sample is whether each student in the survey uses the exercise facility on a regular basis.

(C) The population is the 34,000 students who attend the university, and the sample is whether each student in the survey is male or female.

(D) The population is the 34,000 students who attend the university, and the sample is the 770 students who were selected.

(E) The population is the 34,000 students who attend the university, and the sample is the 493 students who indicated that they use the exercise facilities on a regular basis.

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23. A study will be conducted to examine a new medicine intended to reduce high blood pressure in adult men who have high blood pressure. As part of the study, a random sample of 40 men with high blood pressure will have their blood pressure measured, and then they will take the new medicine every day for one month. At the end of the month, their blood pressure will be measured again. Of the following, which is the best procedure to investigate whether there will be convincing statistical evidence of a change, on average, in blood pressure for men with high blood pressure who take the new medicine?

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

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

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

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

(E) A chi-square test of independence

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GO ON TO THE NEXT PAGE.

24. A roadrunner is a desert bird that tends to run instead of fly. While running, the roadrunner uses its tail as a balance. A sample of 10 roadrunners was taken, and the birds' total length, in centimeters (cm), and tail length, in cm, were recorded. The output shown in the table is from a least-squares regression to predict tail length given total length.

Term	Coef	SE Coef
Constant	–1.281	2.673
Total Length	0.5264	0.0467

Suppose a roadrunner has a total length of 59.0 cm and tail length of 31.1 cm. Based on the residual, does the regression model overestimate or underestimate the tail length of the roadrunner?

(A) Underestimate, because the residual is positive.

(B) Underestimate, because the residual is negative.

(C) Overestimate, because the residual is positive.

(D) Overestimate, because the residual is negative.

(E) Neither, because the residual is 0.

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25. The distribution of assembly times required to assemble a certain smartphone is approximately normal with mean 4.6 minutes and standard deviation 0.6 minute. Of the following, which is closest to the percentage of assembly times between 4 minutes and 5 minutes?

(A) 34%

(B) 41%

(C) 59%

(D) 68%

(E) 95%

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26. A company produces millions of 1-pound packages of bacon every week. Company specifications allow for no more than 3 percent of the 1-pound packages to be underweight. To investigate compliance with the specifications, the company's quality control manager selected a random sample of 1,000 packages produced in one week and found 40 packages, or 4 percent, to be underweight. Assuming all conditions for inference are met, do the data provide convincing statistical evidence at the significance level of $\alpha = 0.05$ that more than 3 percent of all the packages produced in one week are underweight?

(A) Yes, because the sample estimate of 0.04 is greater than the company specification of 0.03.

(B) Yes, because the p-value of 0.032 is less than the significance level of 0.05.

(C) Yes, because the p-value of 0.064 is greater than the significance level of 0.05.

(D) No, because the p-value of 0.032 is less than the significance level of 0.05.

(E) No, because the p-value of 0.064 is greater than the significance level of 0.05.

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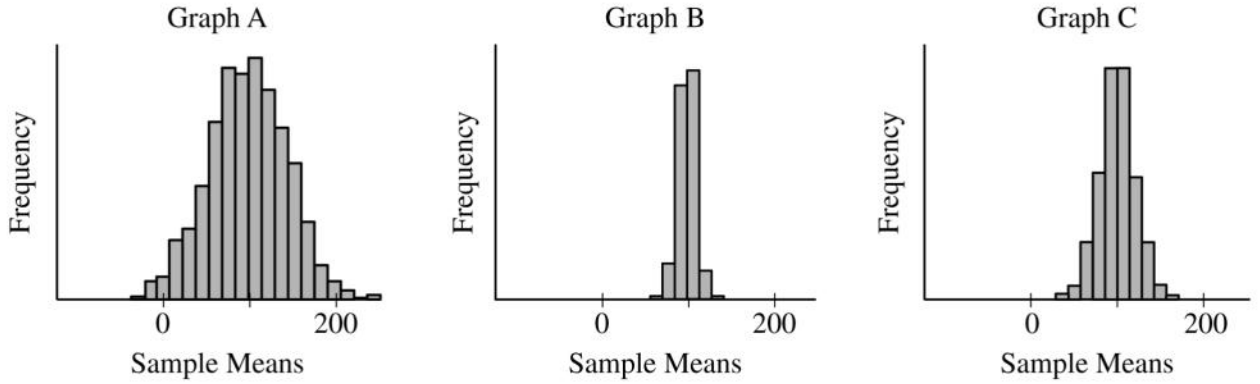
27. The histograms show the results of three simulations of a sampling distribution of a sample mean. For each simulation, 1,500 samples of size n were selected from the same population and the sample mean was recorded. The value of n was different for each of the three simulations.



Which of the following is the correct ordering of the graphs from least value of n to greatest value of n?

(A) A, C, B

(B) B, A, C

(C) B, C, A

(D) C, A, B

(E) C, B, A

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28. Researchers conducted a study to investigate the effects of soft drink consumption on fat stored in muscle tissue. From a sample of 80 adult volunteers, 40 were randomly assigned to consume one liter of a soft drink each day. The remaining 40 were asked to drink one liter of water each day and not to consume any soft drinks. At the end of six months, the amount of fat stored in each person's muscle tissue was recorded. The people in the group who drank the soft drink had, on average, a higher percentage of fat stored in the tissue than the people who drank only water. Which of the following is the most appropriate conclusion?

(A) There is evidence that consuming soft drinks causes more fat storage in muscle tissue than drinking only water, and the conclusion can be generalized to all adults.

(B) There is evidence that consuming soft drinks causes more fat storage in muscle tissue than drinking only water, and the conclusion can be generalized to all people who consume soft drinks.

(C) There is evidence that consuming soft drinks causes more fat storage in muscle tissue than drinking only water, and the conclusion can be generalized to adults similar to those in the study.

(D) Although cause-and-effect cannot be established, there is an association between consuming soft drinks and fat storage in muscle tissue for the population of all adults.

(E) Although cause-and-effect cannot be established, there is an association between consuming soft drinks and fat storage in muscle tissue for the population of all adults who consume soft drinks.

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GO ON TO THE NEXT PAGE.

29. A random sample of 1,018 city residents were asked to rate their level of support for a proposal being considered by the city council. The table shows the responses by level of support.

Level of Support	Number of Responses
Very supportive	336
Somewhat supportive	387
Not supportive	295

Based on the responses, which of the following is a 95 percent confidence interval for the proportion of all city residents who would respond very supportive or somewhat supportive of the proposal?

(A) 0.33 ± 0.029

(B) 0.38 ± 0.030

(C) 0.71 ± 0.058

(D) 0.71 ± 0.031

(E) 0.71 ± 0.028

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GO ON TO THE NEXT PAGE.

30. A manufacturer of cell phone batteries claims that the average number of recharge cycles for its batteries is 400. A consumer group will obtain a random sample of 100 of the manufacturer's batteries and will calculate the mean number of recharge cycles. Which of the following statements is justified by the central limit theorem?

(A) The distribution of the number of recharge cycles for the sample is approximately normal because the population mean of 400 is greater than 30.

(B) The distribution of the number of recharge cycles for the sample is approximately normal because the sample size of 100 is greater than 30.

(C) The distribution of the number of recharge cycles for the population is approximately normal because the sample size of 100 is greater than 30.

(D) The distribution of the sample means of the number of recharge cycles is approximately normal because the sample size of 100 is greater than 30.

(E) The distribution of the sample means of the number of recharge cycles is approximately normal because the population mean of 400 is greater than 30.

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31. A news organization conducted a survey about preferred methods for obtaining the news. A random sample of 1,605 adults living in a certain state was selected, and 16.2 percent of the adults in the sample reported that television was their preferred method. Which of the following is an appropriate margin of error for a 90 percent confidence interval to estimate the population proportion of all adults living in the state who would report that television is their preferred method for obtaining the news?

(A) $1.645\sqrt{\frac{(0.162)(1-0.162)}{1{,}605}}$

(B) $1.645\sqrt{\frac{(0.5)(1-0.5)}{1{,}605}}$

(C) $1.96\sqrt{\frac{(0.162)(1-0.162)}{1{,}605}}$

(D) $1.96\sqrt{\frac{(0.5)(1-0.5)}{1{,}605}}$

(E) $1.83\sqrt{\frac{(0.162)(1-0.162)}{1{,}605}}$

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32. A fitness center offers a one-month program designed to reduce body fat through exercise. The table shows the body fat percentage before and after completing the program for 10 randomly selected participants.

Participant	A	B	C	D	E	F	G	H	I	J
Before (%)	10.8	21.5	18.9	17.0	20.8	24.6	15.4	18.2	19.9	21.2
After (%)	10.7	20.4	19.1	16.1	20.6	22.3	15.5	18.1	18.5	20.0

The director of the program wants to investigate whether knowing the body fat percentage before beginning the program can help to predict body fat percentage for someone who completes the program. Which of the following procedures is the most appropriate for such an investigation?

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

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

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

(D) A chi-square test of association

(E) A linear regression t-test for slope

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GO ON TO THE NEXT PAGE.

33. A recent survey estimated that 19 percent of all people living in a certain region regularly use sunscreen when going outdoors. The margin of error for the estimate was 1 percentage point. Based on the estimate and the margin of error, which of the following is an appropriate conclusion?

(A) Approximately 1% of all the people living in the region were surveyed.

(B) Between 18% and 20% of all the people living in the region were surveyed.

(C) All possible samples of the same size will result in between 18% and 20% of those surveyed indicating they regularly use sunscreen.

(D) The probability is 0.01 that a person living in the region will use sunscreen when going outdoors.

(E) It is plausible that the percent of all people living in the region who regularly use sunscreen is 18.5%.

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GO ON TO THE NEXT PAGE.

34. According to a recent report, customers who shop at a certain online store spend, on average, $1,500 a year at the store. To investigate whether the mean amount spent was greater than the reported average, an economist obtained the mean and standard deviation of the amount spent in the past year by a random sample of 120 customers who shop at the store. With all conditions for inference met, the economist conducted the appropriate hypothesis test and obtained a p-value of 0.25. Which of the following statements is the most appropriate conclusion for the investigation?

(A) There is convincing statistical evidence that the mean amount of money spent each year by all customers who shop at the store is $1,500.

(B) There is convincing statistical evidence that the mean amount of money spent each year by all customers who shop at the store is greater than $1,500.

(C) There is convincing statistical evidence that the mean amount of money spent each year by all customers who shop at the store is less than $1,500.

(D) There is not convincing statistical evidence that the mean amount of money spent each year by all customers who shop at the store is greater than $1,500.

(E) There is not convincing statistical evidence that the mean amount of money spent each year by any sample of 120 customers who shop at the store is greater than $1,500.

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35. Scientists working for a water district measure the water level in a lake each day. The daily water level in the lake varies due to weather conditions and other factors. The daily water level has a distribution that is approximately normal with mean water level of 84.07 feet. The probability that the daily water level in the lake is at least 100 feet is 0.064. Which of the following is closest to the probability that on a randomly selected day the water level in the lake will be at least 90 feet?

(A) 0.29

(B) 0.31

(C) 0.34

(D) 0.37

(E) 0.50

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36. The president of a large company recommends that employees perform, on average, 24 hours of community service each year. The president believes that the mean number of hours of community service performed last year was different from the recommended 24 hours. To estimate the mean number of hours of community service performed last year, the president obtained data from a random sample of employees and used the data to construct the 95 percent confidence interval (20.37, 23.49). If all conditions for inference were met, does the interval provide convincing statistical evidence, at a level of significance of $\alpha = 0.05$, to support the president's belief that the mean number of hours of community service performed last year is different from what is recommended?

(A) Yes, the interval supports the president's belief because 0 is not contained in the interval.

(B) Yes, the interval supports the president's belief because 24 is not contained in the interval.

(C) No, the interval does not support the president's belief because a 90% confidence interval is required for a 5% level of statistical evidence.

(D) No, the interval does not support the president's belief because confidence intervals should only be used for estimation and cannot provide convincing statistical evidence.

(E) No, the interval does not support the president's belief because the significance level is equal to 1 minus the confidence level, indicating that the results are not convincing.

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37. An international polling agency estimates that 36 percent of adults from Country X were first married between the ages of 18 and 32, and 26 percent of adults from Country Y were first married between the ages of 18 and 32. Based on the estimates, which of the following is closest to the probability that the difference in proportions between a random sample of 60 adults from Country X and a random sample of 50 adults from Country Y (Country X minus Country Y) who were first married between the ages of 18 and 32 is greater than 0.15 ?

(A) 0.1398

(B) 0.2843

(C) 0.4315

(D) 0.5685

(E) 0.7157

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38. A consumer group wanted to investigate the relationship between the number of items purchased at a single visit to the local grocery store and the total cost of the items purchased. The group obtained a random sample of 11 receipts from the store and recorded the total number of items and the total cost from each receipt. The computer output of an analysis of total cost versus number of items purchased is shown in the table.

	Estimate	Std Error	t Ratio	Prob > | t |
Intercept	1.882	6.6854	0.28	0.7847
Number of items	2.784	0.2265	12.29	< 0.0001

Assume all conditions for inference were met. Based on the results shown in the table, which of the following is a 95 percent confidence interval for the average change in total cost for each increase of 1 item purchased?

(A) $2.784 \pm 12.29(0.2265)$

(B) $2.784 \pm 2.262(0.2265)$

(C) $2.784 \pm 2.262\left(\frac{0.2265}{\sqrt{11}}\right)$

(D) $1.882 \pm 1.96(6.6854)$

(E) $1.882 \pm 2.262(6.6854)$

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GO ON TO THE NEXT PAGE.

39. A doctor uses a new diagnostic test to indicate whether a patient has a certain disease. The doctor will prescribe medication for the patient if the doctor believes the patient has the disease, as indicated by the diagnostic test. The situation is similar to using a null hypothesis and an alternative hypothesis to decide whether to prescribe the medication. The hypotheses can be stated as follows.

H_0 : The patient does not have the disease.

H_a : The patient has the disease.

Which of the following best describes the power of the test?

(A) The probability that the new test is better than an older test to indicate whether a patient has the disease

(B) The probability that the new test indicates the disease in a patient who has the disease

(C) The probability that the new test indicates the disease in a patient who does not have the disease

(D) The probability that the new test does not indicate the disease in a patient who has the disease

(E) The probability that the new test does not indicate the disease in a patient who does not have the disease

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40. To investigate the relationship between age and preference for two mayoral candidates in an upcoming election, a random sample of city residents was surveyed. The residents were asked which candidate they preferred, and each resident was classified into one of three age-groups. The test statistic for the appropriate hypothesis test was 3.7408. Approximately what is the probability that the observed responses would be as far or farther from the expected responses if there is no association between age-group and preference?

(A) 0.0001

(B) 0.1541

(C) 0.2908

(D) 0.5873

(E) 0.7117

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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**

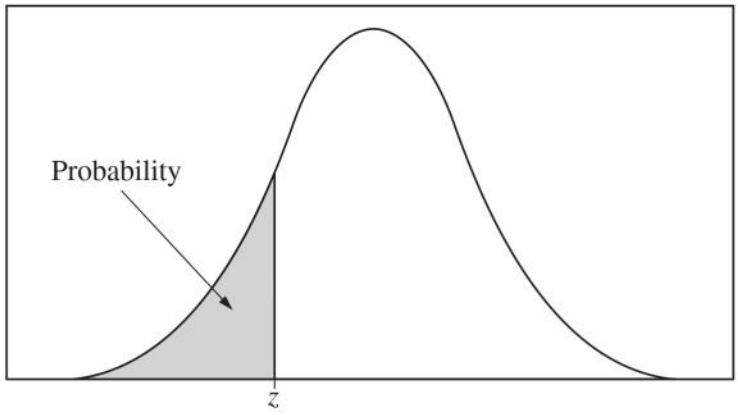


Table entry for z is the probability lying below z.

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

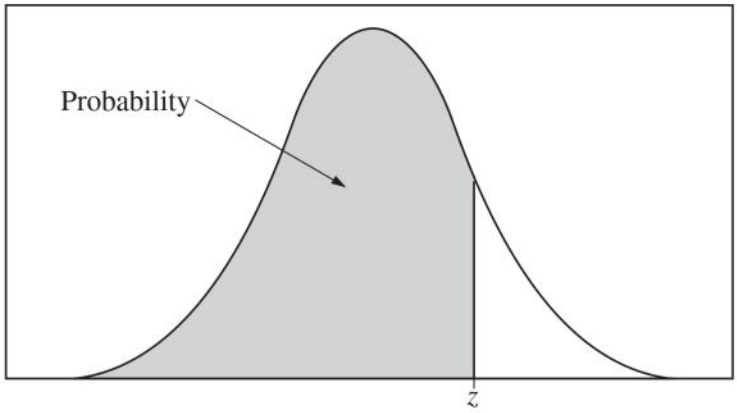


Table entry for z is the probability lying below z.

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^*.

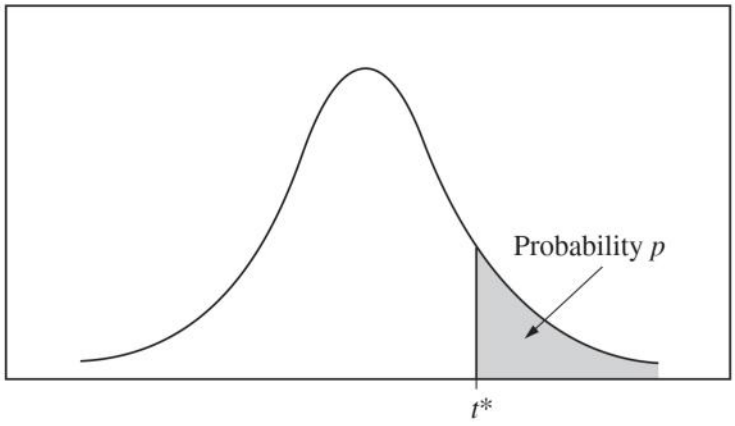


Table B ***t* distribution critical values**

	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.

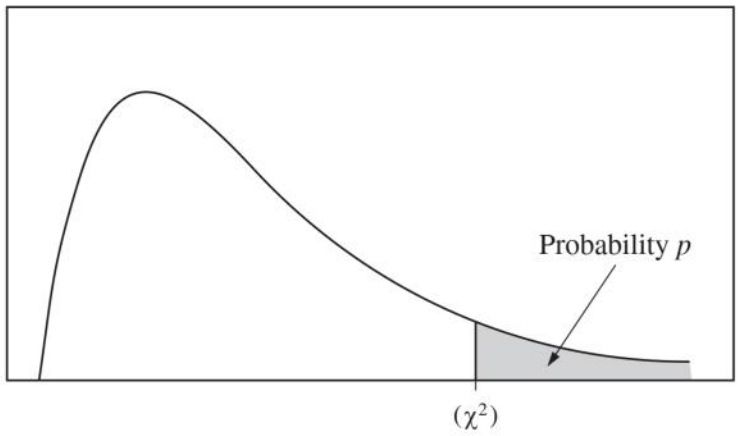


Table C χ^2 critical values

	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

2018

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

At a Glance

Total Time
1 hour and 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 and 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.

Form I
Form Code 4OBP4-S

90

Formulas begin on page 3.
Questions begin on page 6.
Tables begin on page 20.

Formulas

(I) Descriptive Statistics

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

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

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

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

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

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

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

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

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

(II) Probability

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

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

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

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

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 i is the mean of a random sample of size n from an infinite population with mean u and standard deviation o, 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

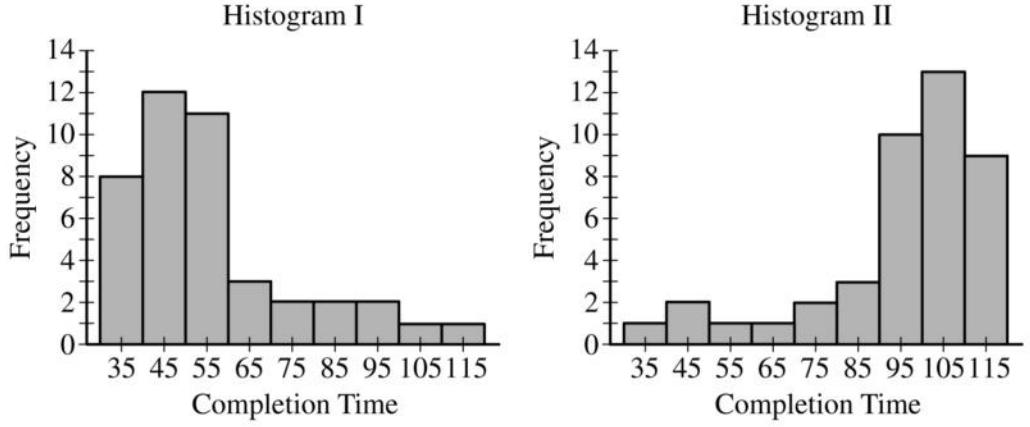
Questions 1-5

Spend about 1 hour and 5 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 students enrolled in honors biology at a high school were given the task of using a spreadsheet program to investigate a topic in genetics. All students in the class had similar background knowledge of the topic. Some students in the class had no spreadsheet experience, Group R, and needed time to learn the program to complete the task. The rest of the students, Group S, had previous spreadsheet experience and typically took less time to complete the task. Each of the histograms below show the distribution of completion times, in minutes, for one of the two groups.



(a) Of the two histograms shown, I and II, which is more likely to be the distribution of completion times for the students in Group R? Justify your answer.

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(b) Describe the shape of a histogram created from the data of the two groups of students combined.

(c) Consider the population of all students in honors biology classes in the high school's state who are given the task of using the spreadsheet program to investigate the topic in genetics. The distribution of the completion times has a shape similar to the combined histogram of students at the high school, with mean 70 minutes and standard deviation 26.5 minutes. For random samples of 50 students taken from the population, describe the sampling distribution of the sample mean completion time.

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2. Researchers are designing an experiment to compare two different types of running shoes, A and B, to investigate which type is better for minimizing running time for a one-mile run. The experiment will consist of distributing the shoes to runners who are classified as either professional or recreational. A randomized block design is planned, with blocking by classification of runner. Random samples of 50 professional runners and 50 recreational runners will be selected. Each runner within each classification will be randomly assigned to wear either the type A shoe or the type B shoe, and their running times will be recorded for a one-mile run.

(a) What is a statistical advantage of blocking by the classification of runner?

(b) Why is it important to randomize the type of shoe the runner will wear instead of allowing the runner to choose the shoe?

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(c) Explain how the design of the experiment will address replication. What is the benefit of the replication?

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3. A large university offers STEM (science, technology, engineering, and mathematics) internships to women in STEM majors at the university. A woman must be 20 years or older to meet the age requirement for the internships. The table shows the probability distribution of the ages of the women in STEM majors at the university.

Age (years)	17	18	19	20	21	22	23 or older
Probability	0.005	0.107	0.111	0.252	0.249	0.213	0.063

(a) Suppose one woman is selected at random from the women in STEM majors at the university. What is the probability that the woman selected will not meet the age requirement for the internships?

The university will select a sample of 100 women in STEM majors to participate in a focus group about the internships.

(b) Suppose a simple random sampling process is used to select the sample of 100 women. What is the probability that at least 30 percent of the women in the sample will not meet the age requirement for the internships?

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(c) Suppose a stratified random sampling design is used to select a sample of 30 women who do not meet the age requirement and a sample of 70 women who do meet the age requirement. Based on the probability distribution, is a woman who does not meet the age requirement more likely, less likely, or equally likely to be selected with a stratified random sample than with a simple random sample? Justify your answer.

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4. Activity trackers are electronic devices that people wear to record physical activity. Researchers wanted to estimate the mean number of steps taken on a typical workday for people working in New York City who wear such trackers. A random sample of 61 people working in New York City who wear an activity tracker was selected. The number of steps taken on a typical workday for each person in the sample was recorded. The mean was 9,797 steps and the standard deviation was 2,313 steps.

   (a) Construct and interpret a 99 percent confidence interval for the mean number of steps taken on a typical workday for all people working in New York City who wear an activity tracker.

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(b) A wellness director at a company in New York City wants to investigate whether it is unusual for one person working in the city who wears an activity tracker to record approximately 8,500 steps on a typical workday. Is it appropriate to use the confidence interval found in part (a) to conduct the investigation? Explain your answer.

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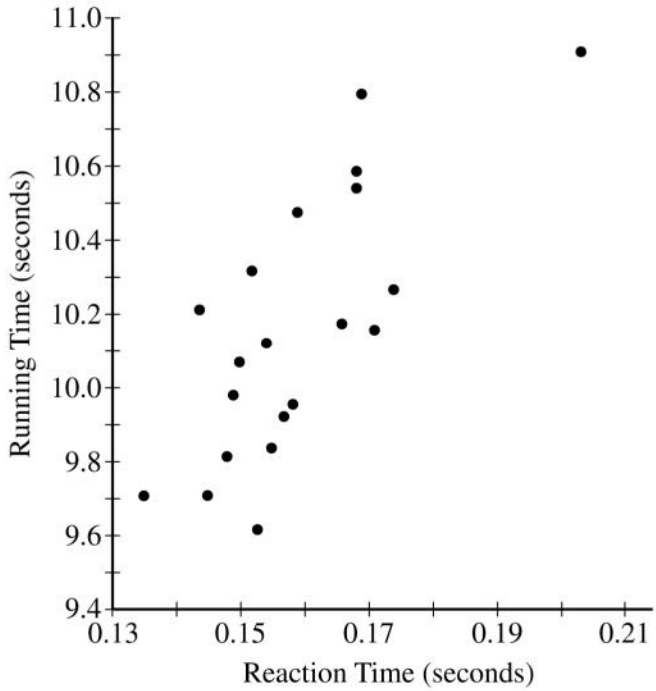
5. The total race time for a 100-meter dash can be considered the sum of two variables: the reaction time to the starting signal and the running time for the 100 meters. The scatterplot shows reaction times and running times for 20 runners in a certain race. The winner was the runner with the least total race time.



(a) Circle the point on the graph that represents the runner who won the race and approximate the total race time for that runner.

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GO ON TO THE NEXT PAGE.

(b) Based on the graph, is it reasonable to assume that reaction time and running time are independent? Justify your answer.

(c) Based on the least-squares regression model created from the data, explain why the use of extrapolation to predict the running time for a runner whose reaction time is 0.30 second might not be appropriate.

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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. A large company produces an equal number of brand-name lightbulbs and generic lightbulbs. The director of quality control sets guidelines that production will be stopped if there is evidence that the proportion of all lightbulbs that are defective is greater than 0.10. The director also believes that the proportion of brand-name lightbulbs that are defective is not equal to the proportion of generic lightbulbs that are defective. Therefore, the director wants to estimate the average of the two proportions.

   To estimate the proportion of brand-name lightbulbs that are defective, a simple random sample of 400 brand-name lightbulbs is taken and 44 are found to be defective. Let X represent the number of brand-name lightbulbs that are defective in a sample of 400, and let p_X represent the proportion of all brand-name lightbulbs that are defective. It is reasonable to assume that X is a binomial random variable.

   (a) One condition for obtaining an interval estimate for p_X is that the distribution of $\hat{p}_X$ is approximately normal. Is it reasonable to assume that the condition is met? Justify your answer.

   (b) The standard error of $\hat{p}_X$ is approximately 0.0156. Show how the value of the standard error is calculated.

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(c) How many standard errors is the observed value of $\hat{p}_X$ from 0.10 ?

To estimate the proportion of generic lightbulbs that are defective, a simple random sample of 400 generic lightbulbs is taken and 104 are found to be defective. Let Y represent the number of generic lightbulbs that are defective in a sample of 400. It is reasonable to assume that Y is a binomial random variable and the distribution of $\hat{p}_Y$ is approximately normal, with an approximate standard error of 0.0219. It is also reasonable to assume that X and Y are independent.

The parameter of interest for the manager of quality control is D, the average proportion of defective lightbulbs for the brand-name and the generic lightbulbs. D is defined as $D = \frac{p_X + p_Y}{2}$.

(d) Consider $\hat{D}$, the point estimate of D.

(i) Calculate $\hat{D}$ using data from the sample of brand-name lightbulbs and the sample of generic lightbulbs.

(ii) Calculate $s_{\hat{D}}$, the standard error of $\hat{D}$.

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GO ON TO THE NEXT PAGE.

Consider the following hypotheses.

H_0 : The average proportion of all lightbulbs that are defective is 0.10. ($D = 0.10$)

H_a : The average proportion of all lightbulbs that are defective is greater than 0.10. ($D > 0.10$)

A reasonable test statistic for the hypotheses is W, defined as $W = \dfrac{\hat{D} - 0.10}{s_{\hat{D}}}$.

(e) Calculate W using your answer to part (d).

(f) Chebyshev's inequality states that the proportion of any distribution that lies within k standard errors of the mean is at least

$$1 - \frac{1}{k^2}.$$

Use Chebyshev's inequality and the value of W to decide whether there is statistical evidence, at the significance level of $\alpha = 0.05$, that D, the average proportion of all lightbulbs that are defective, is greater than 0.10.

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

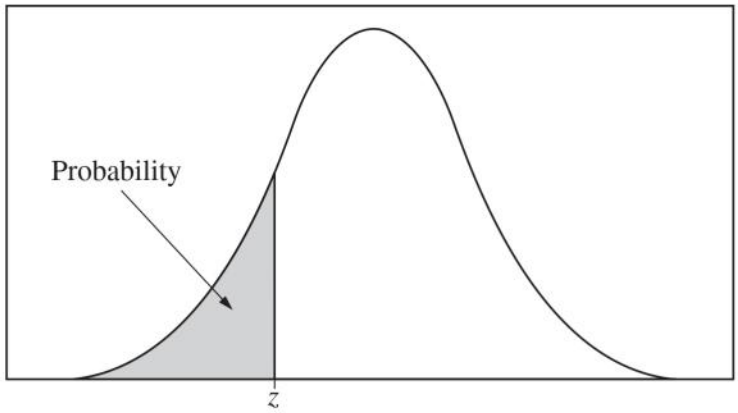

Table entry for z is the probability lying below z.

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

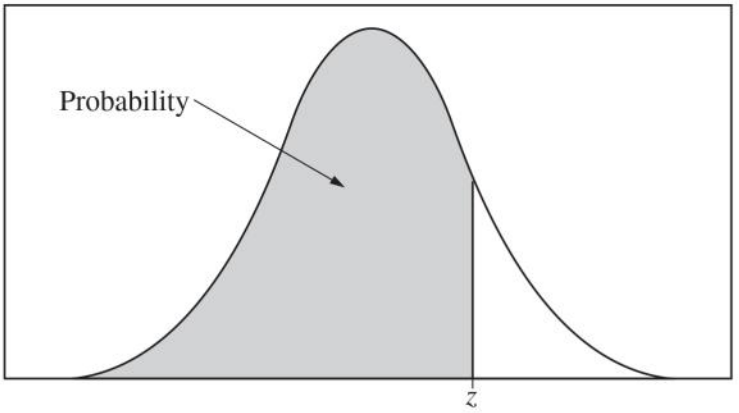

Table entry for z is the probability lying below z.

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^*.

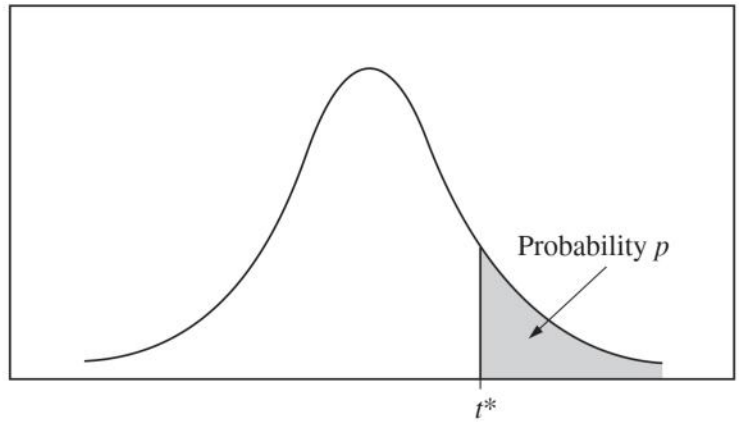

Table B ***t* distribution critical values**

	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.

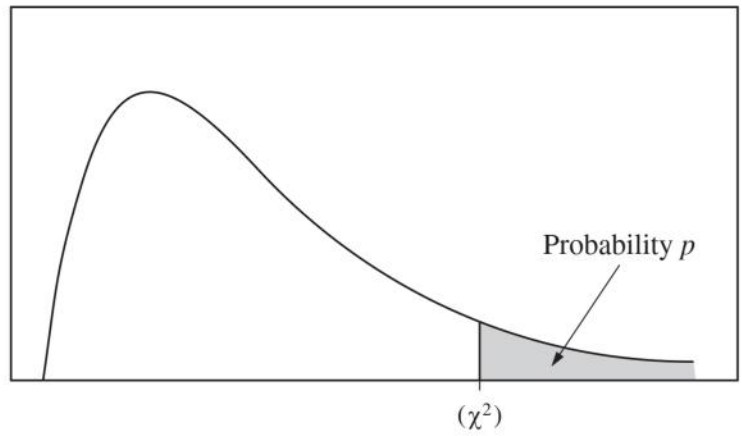

Table C χ^2 critical values

	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