AP® Statistics Exam

SECTION I: Multiple Choice

2017

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 4NBP4-S

90

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. Researchers conducted a telephone survey of 427 adults living in a large city. The adults were asked whether they planned to purchase a smart watch in the next year. The table shows the responses categorized by the region of the city in which the residents live.

	Yes	No
North	24	38
East	32	76
South	38	98
West	23	98

Which of the following graphical displays is most appropriate for comparing the proportions of those surveyed who plan to purchase a smart watch within the four regions?

(A) A scatterplot

(B) A boxplot

(C) A segmented bar chart

(D) A back-to-back stemplot

(E) A dotplot

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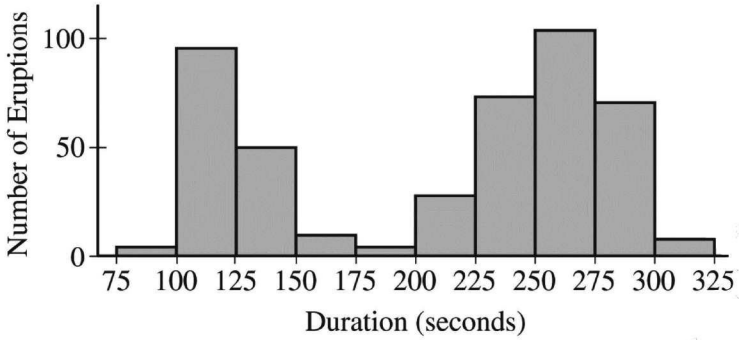
2. A scientist recorded the duration of the eruptions of the Old Faithful geyser in Yellowstone National Park that occurred during a one-month time period. The histogram below shows the distribution of the duration, in seconds, of the eruptions.



Based on the histogram, which of the following is the best description of the distribution?

(A) The distribution is uniform, is centered at about 200 seconds, and has a range of at most 250 seconds.

(B) The distribution is skewed to the left, is centered at about 125 seconds, and has a range of at most 250 seconds.

(C) The distribution is skewed to the right, is centered at about 260 seconds, and has a range of at most 250 seconds.

(D) The distribution displays two clusters, has a range of at most 200 seconds, and includes outliers below 75 seconds and above 325 seconds.

(E) The distribution displays two clusters, with one cluster centered at about 125 seconds and the other centered at about 260 seconds, and has a range of at most 250 seconds.

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3. Events D and E are independent, with $P(D) = 0.6$ and $P(D \text{ and } E) = 0.18$. Which of the following is true?

(A) $P(E) = 0.12$

(B) $P(E) = 0.4$

(C) $P(D \text{ or } E) = 0.28$

(D) $P(D \text{ or } E) = 0.72$

(E) $P(D \text{ or } E) = 0.9$

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4. Researchers used two footballs of the same size to examine the effect of helium on kicking distance. One football was filled with air, and the other was filled with helium. Eleven people participated in the study. Each person kicked the football filled with air and the football filled with helium, and the kicking distances, in yards, were recorded. The football that was kicked first was determined by the flip of a fair coin, and the people did not know which football was filled with air and which was filled with helium. What type of study was conducted by the researchers and, of the following, which is the appropriate t-interval for inference?

(A) A completely randomized design and a t-interval for a difference between means for independent samples

(B) A completely randomized design and a t-interval for a mean difference

(C) A matched-pairs design and a t-interval for a difference between means for independent samples

(D) A matched-pairs design and a t-interval for a mean difference

(E) An observational study and a t-interval for a difference between means for independent samples

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5. A survey of a random sample of 1,045 young adults found that 60 percent do not have a landline telephone number. A hypothesis test will be used to determine whether the data provide convincing statistical evidence that more than 50 percent of all young adults do not have a landline telephone number. Which of the following is the test statistic for the appropriate test?

(A) $\dfrac{0.50 - 0.60}{\sqrt{\dfrac{(0.50)(0.50)}{1,045}}}$

(B) $\dfrac{0.50 - 0.60}{\sqrt{\dfrac{(0.40)(0.60)}{1,045}}}$

(C) $\dfrac{0.60 - 0.50}{\sqrt{\dfrac{(0.50)(0.50)}{1,045}}}$

(D) $\dfrac{0.60 - 0.50}{\sqrt{\dfrac{(0.40)(0.60)}{1,045}}}$

(E) $\dfrac{0.60 - 0.50}{\dfrac{(0.40)(0.60)}{\sqrt{1,045}}}$

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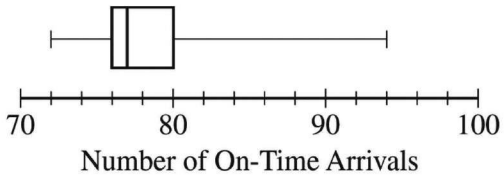
6. An airline recorded the number of on-time arrivals for a sample of 100 flights each day. The boxplot below summarizes the recorded data for one year.



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

(A) The range of the number of on-time arrivals is greater than 90.

(B) The interquartile range of the number of on-time arrivals is 22.

(C) The number of days that had at least 80 on-time arrivals is greater than the number of days that had at most 76 on-time arrivals.

(D) The number of days that had from 76 to 80 on-time arrivals is equal to the number of days that had at most 76 on-time arrivals.

(E) The difference between the median and the lower quartile for the number of on-time arrivals is less than 2.

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7. A tropical storm is classified as major if it has sustained winds greater than 110 miles per hour. Based on data from the past two decades, a meteorologist estimated the following percentages about future storms.

   - 20% of all tropical storms will originate in the Atlantic Ocean, of which 20% will be classified as major.
   - 30% of all tropical storms will originate in the eastern Pacific Ocean, of which 15% will be classified as major.
   - 50% of all tropical storms will originate in the western Pacific Ocean, of which 25% will be classified as major.

   Based on the meteorologist's estimates, approximately what is the probability that a future tropical storm will originate in the Pacific Ocean and be classified as major?

   (A) 0.045

   (B) 0.125

   (C) 0.170

   (D) 0.400

   (E) 0.960

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8. Research indicates that the standard deviation of typical human body temperature is 0.4 degree Celsius (C). Which of the following represents the standard deviation of typical human body temperature in degrees Fahrenheit (F), where $F = \frac{9}{5}C + 32$?

(A) $\frac{9}{5}(0.4) + 32$

(B) $\frac{9}{5}(0.4)$

(C) $\frac{9}{5}(0.4)^2$

(D) $\left(\frac{9}{5}\right)^2(0.4)$

(E) $\left(\frac{9}{5}\right)^2(0.4)^2$

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9. The distribution of weights of female college cross-country runners is approximately normal with mean 122 pounds and standard deviation 8 pounds. Which of the following is closest to the percent of the runners who weigh between 114 pounds and 138 pounds?

(A) 18%

(B) 32%

(C) 68%

(D) 82%

(E) 95%

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10. Measurements of water quality were taken from a river downstream from an abandoned chemical dumpsite. Concentrations of a certain chemical were obtained from 9 measurements taken at the surface of the water, 9 measurements taken at mid-depth of the water, and 9 measurements taken at the bottom of the water. What type of study was conducted, and what is the response variable of the study?

(A) An experiment was conducted, and the response variable is the concentration of the chemical.

(B) An experiment was conducted, and the response variable is the depth of the water.

(C) A census was conducted, and the response variable is the depth of the water.

(D) An observational study was conducted, and the response variable is the concentration of the chemical.

(E) An observational study was conducted, and the response variable is the depth of the water.

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11. Ecologists wanted to estimate the mean biomass (amount of vegetation) of a certain forested region. The ecologists divided the region into plots measuring 1 square meter each, and they selected a random sample of 9 plots. The mean biomass of the 9 plots was 4.3 kilograms per square meter (kg/m^2) and the standard deviation was 1.5 kg/m^2. Assuming all conditions for inference are met, which of the following is a 95 percent confidence interval for the population mean biomass, in kg/m^2 ?

(A) $4.3 \pm 1.96\left(\frac{\sqrt{1.5}}{3}\right)$

(B) $4.3 \pm 1.96\left(\frac{1.5}{3}\right)$

(C) $4.3 \pm 2.306\left(\frac{\sqrt{1.5}}{9}\right)$

(D) $4.3 \pm 2.306\left(\frac{1.5}{9}\right)$

(E) $4.3 \pm 2.306\left(\frac{1.5}{3}\right)$

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12. Staff members of a high school newspaper want to obtain an estimate of the average number of years teachers in the state have been teaching. At an educational conference attended by many teachers in the state, the staff members randomly selected 50 conference attendees and asked the attendees how long they have been teaching. Which of the following describes the sample and the population to which it would be most reasonable for the staff members to generalize the results?

(A) The sample is the 50 conference attendees, and the population is all teachers in the state.

(B) The sample is the 50 conference attendees, and the population is all conference attendees.

(C) The sample is all conference attendees, and the population is all teachers in the state.

(D) The sample is all conference attendees, and the population is the 50 conference attendees.

(E) The sample is the average number of years that all conference attendees have taught, and the population is all conference attendees.

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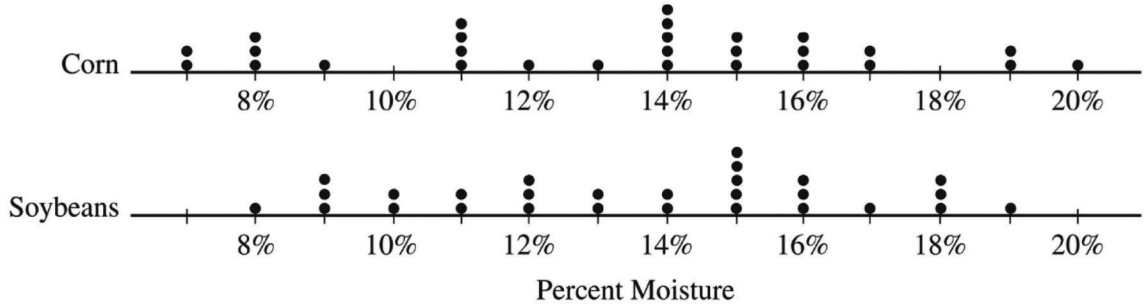
13. Grain moisture is a characteristic of grain that affects the price paid for the grain. A random sample of 28 loads of corn was evaluated for moisture as a percent of the total weight. A different random sample of 28 loads of soybeans was also evaluated for moisture. The data are displayed in the dotplots below.



Based on the dotplots, which of the following is greater for the percent moisture of corn than for the percent moisture of soybeans?

(A) The first quartile

(B) The median

(C) The third quartile

(D) The range

(E) The interquartile range

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14. A sleep time of 15.9 hours per day for a newborn baby is at the 10th percentile of the distribution of sleep times for all newborn babies. Assuming the distribution is normal with standard deviation 0.5 hour, approximately what is the mean sleep time, in hours per day, for newborn babies?

(A) 15.1

(B) 15.3

(C) 16.3

(D) 16.5

(E) 16.7

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15. As part of a science experiment, a student recorded 10 measurements of the temperature of a liquid. One of the measurements was an outlier when compared with the other 9 measurements. Which of the following must be true about the 9 measurements, excluding the outlier, when compared with the 10 measurements? (Note: An outlier is any number that is greater than the upper quartile or less than the lower quartile by at least 1.5 times the interquartile range.)

(A) The median of the 9 measurements is less than the median of the 10 measurements.

(B) The median of the 9 measurements is greater than the median of the 10 measurements.

(C) The maximum of the 9 measurements is less than the maximum of the 10 measurements.

(D) The maximum of the 9 measurements is greater than the maximum of the 10 measurements.

(E) The standard deviation of the 9 measurements is less than the standard deviation of the 10 measurements.

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16. At a local ice-cream store, 210 people were surveyed on whether they preferred eating ice cream from a cone or a cup. Of the 210 people surveyed, 70 were adults and 140 were children. Of the responses, 150 indicated the cone as the preferred method of eating ice cream. For those surveyed, there was no association between age and preferred method of eating ice cream. Which of the following tables shows the distribution of responses?

(A)

	Cone	Cup	Total
Adults	35	35	70
Children	115	25	140
Total	150	60	210

(B)

	Cone	Cup	Total
Adults	40	30	70
Children	110	30	140
Total	150	60	210

(C)

	Cone	Cup	Total
Adults	50	20	70
Children	100	40	140
Total	150	60	210

(D)

	Cone	Cup	Total
Adults	60	10	70
Children	90	50	140
Total	150	60	210

(E)

	Cone	Cup	Total
Adults	65	5	70
Children	85	55	140
Total	150	60	210

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17. A two-sided t-test for a population mean is conducted of the null hypothesis $H_0 : \mu = 100$. If a 90 percent t-interval constructed from the same sample data contains the value of 100, which of the following can be concluded about the test at a significance level of $\alpha = 0.10$?

(A) The p-value is less than 0.10, and H_0 should be rejected.

(B) The p-value is less than 0.10, and H_0 should not be rejected.

(C) The p-value is greater than 0.10, and H_0 should be rejected.

(D) The p-value is greater than 0.10, and H_0 should not be rejected.

(E) There is not enough information given to make a conclusion about the p-value and H_0.

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18. An agriculturalist working with Australian pine trees wanted to investigate the relationship between the age and the height of the Australian pine. A random sample of Australian pine trees was selected, and the age, in years, and the height, in meters, was recorded for each tree in the sample. Based on the recorded data, the agriculturalist created the following regression equation to predict the height, in meters, of the Australian pine based on the age, in years, of the tree.

$$\text{predicted height} = 0.29 + 0.48(\text{age})$$

Which of the following is the best interpretation of the slope of the regression line?

(A) The height increases, on average, by 1 meter each 0.48 year.

(B) The height increases, on average, by 0.48 meter each year.

(C) The height increases, on average, by 0.29 meter each year.

(D) The height increases, on average, by 0.29 meter each 0.48 year.

(E) The difference between the actual height and the predicted height is, on average, 0.48 meter for each year.

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19. At a certain store, the distribution of weights of cartons of large eggs is approximately normal with mean 26 ounces (oz). Based on the distribution, which of the following intervals will contain the greatest proportion of cartons of large eggs at the store?

(A) 20 oz to 24 oz

(B) 22 oz to 26 oz

(C) 24 oz to 28 oz

(D) 26 oz to 30 oz

(E) 28 oz to 32 oz

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20. In 1960 sociologists studied a random sample of 1,018 families that consisted of a husband, a wife, and at least one child. Of those families, 5.8 percent reported that the wife was the primary wage earner of the family. In 2011 the study was replicated with a random sample of 1,013 families that consisted of a husband, a wife, and at least one child. Of those families, 22.3 percent reported that the wife was the primary wage earner of the family. Which of the following represents a 99 percent confidence interval for the difference between the proportions of families that consisted of a husband, a wife, and at least one child from 1960 to 2011 that would have reported the wife as the primary wage earner?

(A) $(0.223 - 0.058) \pm 1.96\sqrt{\frac{(0.223)(0.777)}{1,013} + \frac{(0.058)(0.942)}{1,018}}$

(B) $(0.223 - 0.058) \pm 2.326\sqrt{\frac{(0.223)(0.777)}{1,013} + \frac{(0.058)(0.942)}{1,018}}$

(C) $(0.223 - 0.058) \pm 2.576\sqrt{\frac{(0.223)(0.777)}{1,013} + \frac{(0.058)(0.942)}{1,018}}$

(D) $(0.223 - 0.058) \pm 2.326\sqrt{\frac{285}{2,031}\left(\frac{1}{1,013} + \frac{1}{1,018}\right)}$

(E) $(0.223 - 0.058) \pm 2.576\sqrt{\frac{285}{2,031}\left(\frac{1}{1,013} + \frac{1}{1,018}\right)}$

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21. Researchers working for a certain airline are investigating the weight of carry-on bags. The researchers will use the mean weight of a random sample of 800 carry-on bags to estimate the mean weight of all carry-on bags for the airline. Which of the following best describes the effect on the bias and the variance of the estimator if the researchers increase the sample size to 1,300 ?

(A) The bias will decrease and the variance will remain the same.

(B) The bias will increase and the variance will remain the same.

(C) The bias will remain the same and the variance will decrease.

(D) The bias will remain the same and the variance will increase.

(E) The bias will decrease and the variance will decrease.

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22. Researchers investigated whether a new process for producing yarn could reduce the mean amount of volatile organic compounds (VOCs) emitted by carpet. From random samples of carpets, the researchers found the mean reduction of VOCs emitted by carpets made with yarn produced by the new process compared with that of carpets made with yarn produced by the traditional process was 13 parts per million (ppm). All conditions for inference were met, and the *p*-value for the appropriate hypothesis test was 0.095. Which of the following statements is the best interpretation of the p-value?

(A) The probability that the null hypothesis is true is 0.095.

(B) The probability that the alternative hypothesis is true is 0.095.

(C) The probability of observing a mean reduction of 13 ppm is 0.095.

(D) If the null hypothesis is true, the probability of observing a mean reduction of at least 13 ppm is 0.095.

(E) If the null hypothesis is true, the probability of observing a mean reduction of at most 13 ppm is 0.095.

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23. A 99 percent one-sample z-interval for a proportion will be created from the point estimate obtained from each of two random samples selected from the same population: sample R and sample S. Let R represent a random sample of size 1,000, and let S represent a random sample of size 4,000. If the point estimate obtained from R is equal to the point estimate obtained from S, which of the following must be true about the respective margins of error constructed from those samples?

(A) The margin of error for S will be 4 times the margin of error for R.

(B) The margin of error for S will be 2 times the margin of error for R.

(C) The margin of error for S will be equal to the margin of error for R.

(D) The margin of error for R will be 4 times the margin of error for S.

(E) The margin of error for R will be 2 times the margin of error for S.

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24. A study was conducted to evaluate the impact of taking a nutritional supplement on a person's reaction time. One hundred volunteers were placed into one of three groups according to their athletic ability: low, moderate, or high. Participants in each group were randomly assigned to take either the nutritional supplement or a placebo for six weeks. At the end of the six weeks, participants were given a coordination task. The reaction time in completing the task was recorded for each participant. The study compared the reaction times between those taking the supplement and those taking the placebo within each athletic ability level. Which of the following is the best description of the study?

(A) A randomized block design

(B) A completely randomized design

(C) A matched-pairs design

(D) A randomized observational study

(E) A stratified observational study

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25. The number of tickets purchased by a customer for a musical performance at a certain concert hall can be considered a random variable. The table below shows the relative frequency distribution for the number of tickets purchased by a customer.

Number of tickets purchased	1	2	3	4	5
Relative frequency	0.20	0.45	0.10	0.20	0.05

Suppose each ticket for a certain musical performance cost $12. Based on the distribution shown, what is the mean cost per customer for the performance?

(A) $2.45

(B) $2.75

(C) $24.50

(D) $29.40

(E) $36.00

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26. A survey of a random sample of 210 male teens and 228 female teens, ages 13 years to 17 years, found that 122 of the male teens and 160 of the female teens brush their teeth at least twice a day. If there is no difference between the proportions in the population of all male and female teens ages 13 years to 17 years who brush their teeth at least twice a day, approximately how many males and females in the sample would be expected to brush their teeth at least twice a day?

(A) 105 males and 114 females

(B) 122 males and 160 females

(C) 135 males and 147 females

(D) 141 males and 141 females

(E) 219 males and 219 females

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27. Researchers believed that an increase in lean body mass is associated with an increase in maximal oxygen uptake. A scatterplot of the measurements taken from 18 randomly selected college athletes displayed a strong positive linear relationship between the two variables. A significance test for the null hypothesis that the slope of the regression line is 0 versus the alternative that the slope is greater than 0 yielded a p-value of 0.04. Which statement is an appropriate conclusion for the test?

(A) The p-value of 0.04 indicates that 4% of the variation in maximal oxygen uptake for college athletes can be explained by the amount of lean body mass.

(B) The p-value of 0.04 indicates that 16% of the variation in maximal oxygen uptake for college athletes can be explained by the amount of lean body mass.

(C) The strong positive linear relationship displayed in the scatterplot along with a p-value less than 0.05 indicates that college athletes with higher lean body mass tend to have higher maximal oxygen uptake.

(D) The strong positive linear relationship displayed in the scatterplot along with a p-value less than 0.05 indicates that an increase in lean body mass causes an increase in maximal oxygen uptake for college athletes.

(E) A p-value less than 0.05 indicates that the relationship displayed in the scatterplot is likely due to chance, and that there is no statistical evidence of a relationship between lean body mass and maximal oxygen uptake for college athletes.

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28. An environmental group wanted to estimate the proportion of fresh produce sales identified as organic in a local grocery store. In the winter, the group obtained a random sample of sales from the store and used the data to construct the 95 percent z-interval for a proportion $(0.087, 0.133)$. Six months later in the summer, the group obtained a second random sample of sales from the store. The second sample was the same size as the first, and the proportion of sales identified as organic was 0.4. How does the 95 percent z-interval for a proportion constructed from the summer sample compare to the winter interval?

(A) The summer interval is wider and has a lesser point estimate.

(B) The summer interval is wider and has a greater point estimate.

(C) The summer interval is narrower and has a lesser point estimate.

(D) The summer interval is narrower and has a greater point estimate.

(E) The summer interval is the same width and has a greater point estimate.

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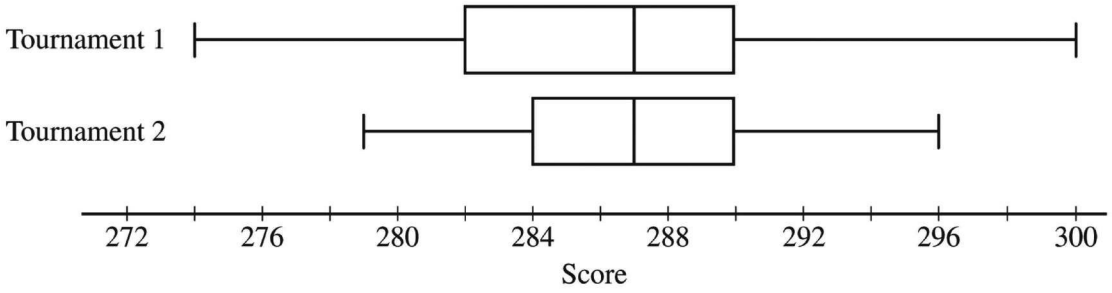
29. In a standard golf tournament, golfers play 18 holes of golf on each of 4 consecutive days. For each hole, golfers keep track of the number of times they hit the ball (strokes) before the ball goes into the cup. A golfer's score for the tournament is the total number of strokes needed to complete the tournament. The boxplots below summarize the scores for golfers who competed in tournament 1 and golfers who competed in tournament 2.



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

(A) More golfers played in tournament 1 than in tournament 2.

(B) In both tournaments, at least half the golfers completed the tournament with a score less than 288.

(C) The number of golfers who completed tournament 1 with a score less than 288 was greater than the number of golfers who completed tournament 2 with a score less than 288.

(D) The range of scores for tournament 1 is less than the range of scores for tournament 2.

(E) The score of the golfer with the least score in tournament 1 was greater than the score of the golfer with the least score in tournament 2.

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30. Based on records kept at a gas station, the distribution of gallons of gas purchased by customers is skewed to the right with mean 10 gallons and standard deviation 4 gallons. A random sample of 64 customer receipts was selected, and the sample mean number of gallons was recorded. Suppose the process of selecting a random sample of 64 receipts and recording the sample mean number of gallons was repeated for a total of 100 samples. Which of the following is the best description of a dotplot created from the 100 sample means?

(A) The dotplot is skewed to the right with mean 10 gallons and standard deviation 4 gallons.

(B) The dotplot is skewed to the right with mean 10 gallons and standard deviation 0.5 gallon.

(C) The dotplot is skewed to the right with mean 10 gallons and standard deviation 0.4 gallon.

(D) The dotplot is approximately normal with mean 10 gallons and standard deviation 0.5 gallon.

(E) The dotplot is approximately normal with mean 10 gallons and standard deviation 0.4 gallon.

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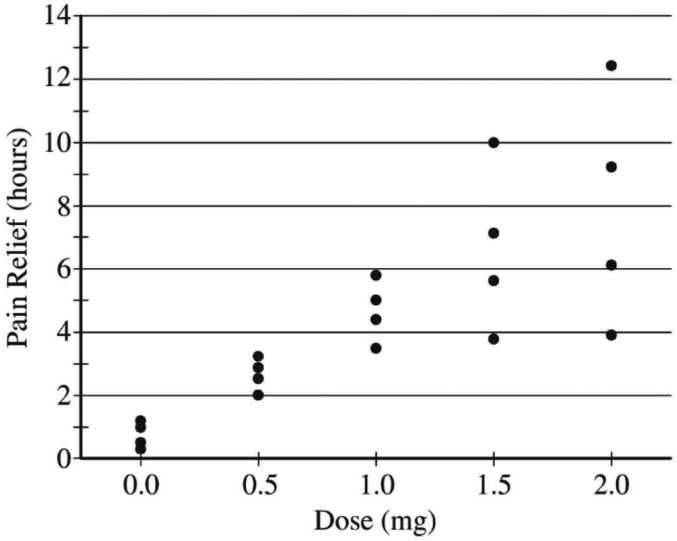
31. An experiment was conducted to investigate the relationship between the dose of a pain medication and the number of hours of pain relief. Twenty individuals with chronic pain were randomly assigned to one of five doses—0.0, 0.5, 1.0, 1.5, 2.0—in milligrams (mg) of medication. The results are shown in the scatterplot below.



The data were used to fit a least-squares regression line to predict the number of hours of pain relief for a given dose. Which of the following would be revealed by a plot of the residuals of the regression versus the dose?

(A) The sum of the residuals is less than 0.

(B) The sum of the residuals is greater than 0.

(C) There are outliers associated with the lower doses.

(D) The variation in the hours of pain relief is not the same across the doses.

(E) There is a positive linear relationship between the residuals and the dose.

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32. A large store has a customer service department where customers can go to ask for help with store-related issues. According to store records, approximately $\frac{1}{4}$ of all customers who go to the service department ask for help finding an item. Assume the reason each customer goes to the service department is independent from customer to customer. Based on the approximation, what is the probability that at least 1 of the next 4 customers who go to the service department will ask for help finding an item?

(A) $4\left(\frac{1}{4}\right)$

(B) $1-\left(\frac{1}{4}\right)^4$

(C) $1-\left(\frac{3}{4}\right)^4$

(D) $4\left(\frac{1}{4}\right)^1\left(\frac{3}{4}\right)^3$

(E) $\left(\frac{4}{4}\right)\left(\frac{3}{4}\right)\left(\frac{2}{4}\right)\left(\frac{1}{4}\right)$

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33. Data were collected from a longitudinal study designed to investigate the relationship between blood sugar levels and brain shrinkage. The results of an analysis of the data for 22 observations are shown in the table below.

Term	Coef	SE Coef
Constant	−15.668	6.154
Blood sugar	0.161	0.073

Which of the following represents a 98 percent confidence interval for the slope of the least-squares regression line for brain shrinkage on blood sugar levels? Assume the conditions for inference are met.

(A) $-15.668 \pm 2.528(6.154)$

(B) $-15.668 \pm 2.518(6.154)$

(C) $0.161 \pm 2.528(0.073)$

(D) $0.161 \pm 2.518(0.073)$

(E) $0.161 \pm 2.197(0.073)$

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34. In a certain computer card game, the player is awarded 5 points for each card that is moved to a correct position. The player is penalized 10 points for each minute the game is played. Let the random variable X represent the number of cards moved to a correct position, and let the random variable Y represent the number of minutes the game is played. The means and standard deviations of the random variables for a particular player are shown in the table below.

Variable	Mean	Standard Deviation
X	9.5	12.9
Y	5.4	1.1

Assume that X and Y are independent. What are the expected value and the standard deviation of the points per game for the player?

(A) The expected value is -6.5, and the standard deviation is 63.5.

(B) The expected value is -6.5, and the standard deviation is 65.4.

(C) The expected value is 4.1, and the standard deviation is 63.5.

(D) The expected value is 4.1, and the standard deviation is 65.4.

(E) The expected value is 101.5, and the standard deviation is 63.5.

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35. A program that was intended to cure a person's fear of spiders was offered at a local zoo. Volunteers with a fear of spiders participated in the program, which included holding a spider for 15 minutes. One month after they completed the program, the participants were contacted and surveyed about the program. Over 90 percent of the participants claimed they were cured of their fear of spiders. Based on the description of the program, which of the following statements is true?

(A) Because over 90% of the participants claimed to be cured, the results prove that holding a spider will cure a person's fear of spiders.

(B) Because over 90% of the participants claimed to be cured, the results can be generalized to the population of all people who have a fear of spiders.

(C) Because the participants were volunteers, the study is a census of all people in the local area who have a fear of spiders.

(D) Because the participants were self-selected, a person's desire to be cured could be a confounding variable.

(E) Because participants held a spider for 15 minutes, the study is an experiment and the results can be generalized to the population of all people who have a fear of spiders.

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36. A police officer uses a motion detector to indicate whether a car is traveling faster than the speed limit (speeding). A speeding ticket will be issued to the driver of the car if the officer believes the driver is speeding, as indicated by the detector. The situation is similar to using a null and an alternative hypothesis to decide whether to issue a ticket. The hypotheses can be stated as follows.

H_0 : The driver is not speeding.

H_a : The driver is speeding.

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

(A) The probability of issuing a ticket to a driver who is speeding

(B) The probability of issuing a ticket to a driver who is not speeding

(C) The probability of not issuing a ticket to a driver who is speeding

(D) The probability of not issuing a ticket to a driver who is not speeding

(E) The probability that the motion detector is working correctly

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37. An agricultural scientist wanted to compare the effect of a new fertilizer to that of three older fertilizers—X, Y, and Z—on the growth of vegetables typically grown in small gardens. Two hundred green bean seedlings were individually planted in identical pots and randomly assigned to one of four groups of 50 each. Seedlings in one group were given the new fertilizer, and the three remaining groups of seedlings were given fertilizers X, Y, or Z, respectively. At the end of four weeks, all seedlings were dried and weighed. The scientist found that the mean weight of the seedlings in the group given the new fertilizer was significantly greater than the mean weights of seedlings in the other three groups. The scientist concluded that the new fertilizer was more effective than the other fertilizers for all vegetables. Why is the scientist's conclusion not appropriate?

(A) The study was observational, so cause and effect cannot be concluded.

(B) The study was observational, so no replication was used in the study.

(C) The experiment only included green beans, so the results cannot be generalized to all vegetables.

(D) The experiment did not group the seedlings into blocks by the variety of beans.

(E) The experiment lacked a control group that did not use any fertilizer.

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38. In a physics experiment, two different methods were used to measure the angle of deflection when a subatomic particle collides with a certain material. Ten specimens of the material were used to compare the two methods. For each specimen, the angle of deflection was measured using both methods. For each specimen, the method used first was determined by the flip of a fair coin. The difference between the measured angles was calculated for each specimen. A test of the hypothesis that the population mean difference is zero had a p-value of 0.082.

The hypothesis test described had three components: the number of specimens, the sample standard deviation of the differences, and the magnitude of the sample mean difference. Compared to the test described, which of the following would have resulted in a smaller p-value?

(A) The number of specimens and the sample standard deviation of the differences remained the same, but the magnitude of the sample mean difference was smaller.

(B) The number of specimens and the magnitude of the sample mean difference remained the same, but the sample standard deviation of the differences was larger.

(C) The number of specimens remained the same, but the magnitude of the sample mean difference was smaller and the sample standard deviation of the difference was larger.

(D) The number of specimens remained the same, but the magnitude of the sample mean difference was larger and the sample standard deviation of the difference was smaller.

(E) The magnitude of the sample mean difference and the sample standard deviation of the differences remained the same, but the number of specimens was smaller.

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39. A polling agency reported that 66 percent of adults living in the United States were satisfied with their health care plans. The estimate was taken from a random sample of 1,542 adults living in the United States, and the 95 percent confidence interval for the population proportion was calculated as $(0.636, 0.684)$. Which of the following statements is a correct interpretation of the 95 percent confidence level?

(A) The probability is 0.95 that the percent of adults living in the United States who are satisfied with their health care plans is between 63.6% and 68.4%.

(B) Approximately 95% of random samples of the same size from the population will result in a confidence interval that includes the proportion of all adults living in the United States who are satisfied with their health care plans.

(C) Approximately 95% of random samples of the same size from the population will result in a confidence interval that includes the proportion of all adults in the sample who are satisfied with their health care plans.

(D) Approximately 95% of all random samples of adults living in the United States will indicate that between 63.6% and 68.4% of the adults are satisfied with their health care plans.

(E) Approximately 95% of all random samples of adults living in the United States will result in a sample proportion of 0.66 adults living in the United States who are satisfied with their health care plans.

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40. A survey was conducted in a large city to investigate public opinion on banning the use of trans fats in restaurant cooking. A random sample of 230 city residents with school-age children was selected, and another random sample of 341 city residents without school-age children was also selected. Of those with school-age children, 94 opposed the banning of trans fats, and of those without school-age children, 147 opposed the banning of trans fats. An appropriate hypothesis test was conducted to investigate whether there was a difference between the two groups of residents in their opposition to the banning of trans fats. Is there convincing statistical evidence of a difference between the two population proportions at the significance level of 0.05 ?

(A) Yes, because the sample proportions are different.

(B) Yes, because the probability of observing a difference at least as large as the sample difference is greater than 0.05.

(C) Yes, because the probability of observing a difference at least as large as the sample difference, if the two population proportions are the same, is less than 0.05.

(D) No, because the probability of observing a difference at least as large as the sample difference, if the two population proportions are the same, is greater than 0.05.

(E) No, because the probability of observing a difference at least as large as the sample difference is less than 0.05.

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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**

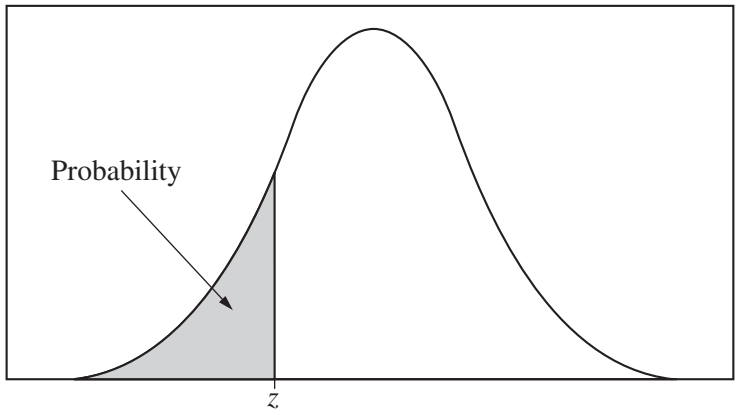

Table entry for z is the probability lying below z.

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.

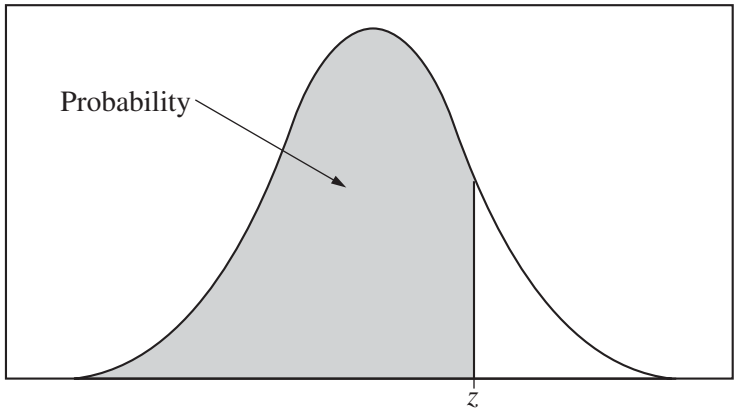

Table A (*Continued*)

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^*.

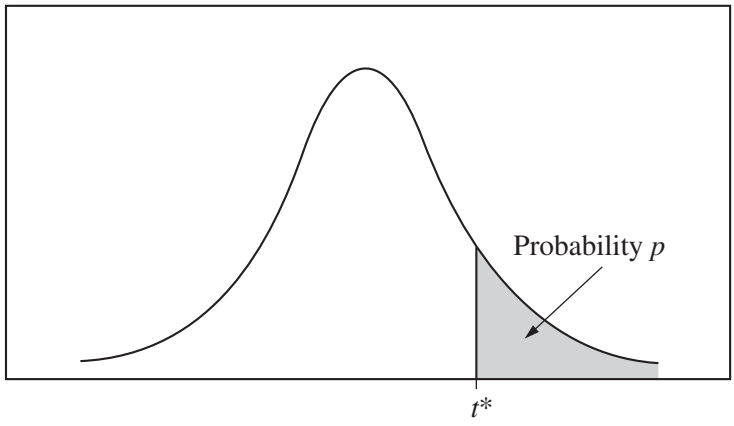

Table B ***t* distribution critical values**

	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.

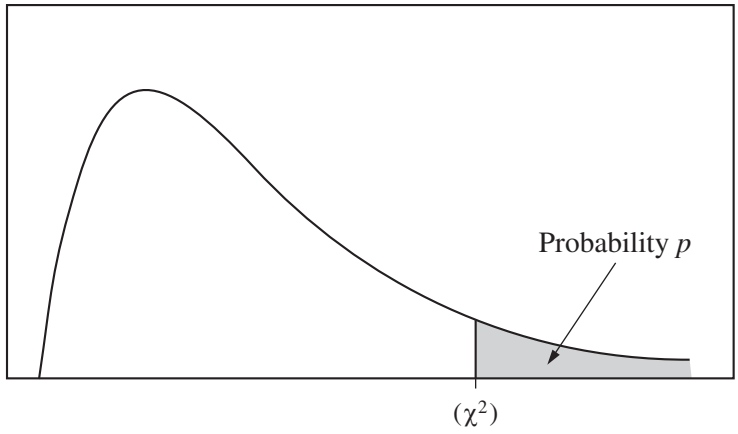

Table C χ^2 critical values

	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

2017

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

At a Glance

Total Time
1 hour, 30 minutes
Number of Questions
6
Percent of Total Score
50%
Writing Instrument
Either pencil or pen with black or dark blue ink
Electronic Device
Graphing calculator expected

Part A

Number of Questions
5
Suggested Time
1 hour, 5 minutes
Percent of Section II Score
75%

Part B

Number of Questions
1
Suggested Time
25 minutes
Percent of Section II Score
25%

IMPORTANT Identification Information

PLEASE PRINT WITH PEN:

1. First two letters of your last name ☐☐
   First letter of your first name ☐
2. Date of birth
   ☐☐ Month ☐☐ Day ☐☐☐☐ Year
3. Six-digit school code
   ☐☐☐☐☐☐
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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 4NBP4-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

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

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

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

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

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

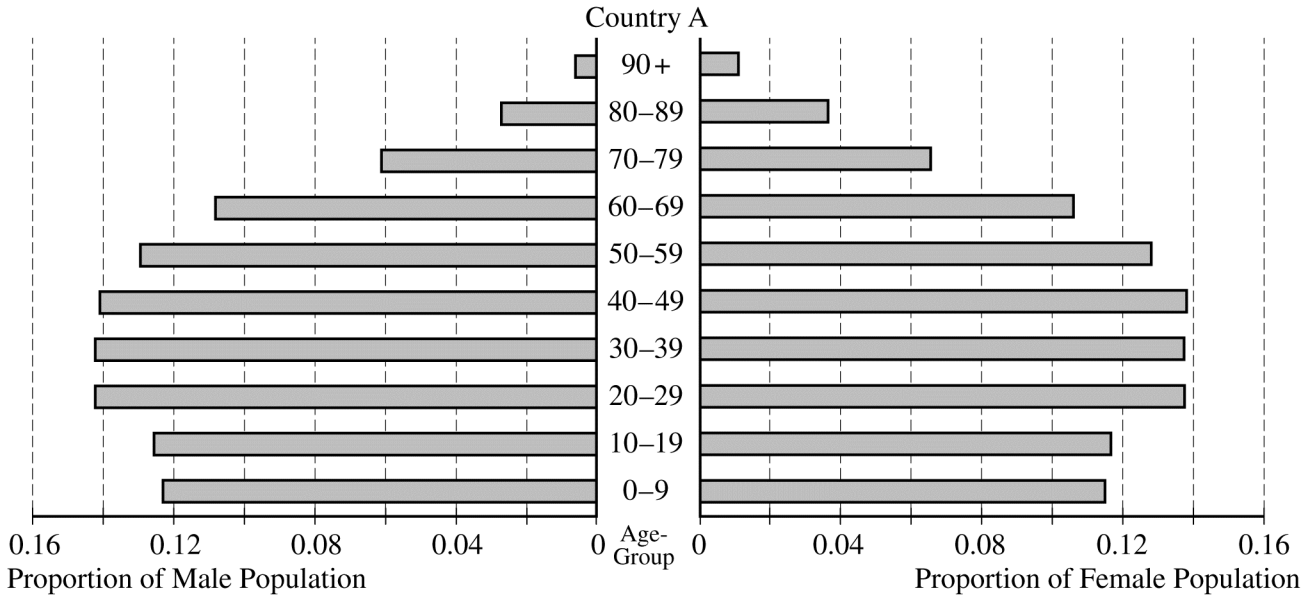
Statistic	Standard Deviation of Statistic
Difference of sample means	$\sqrt{\dfrac{\sigma_1^2}{n_1} + \dfrac{\sigma_2^2}{n_2}}$ Special case when $\sigma_1 = \sigma_2$ $\sigma\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}$
Difference of sample proportions	$\sqrt{\dfrac{p_1(1-p_1)}{n_1} + \dfrac{p_2(1-p_2)}{n_2}}$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

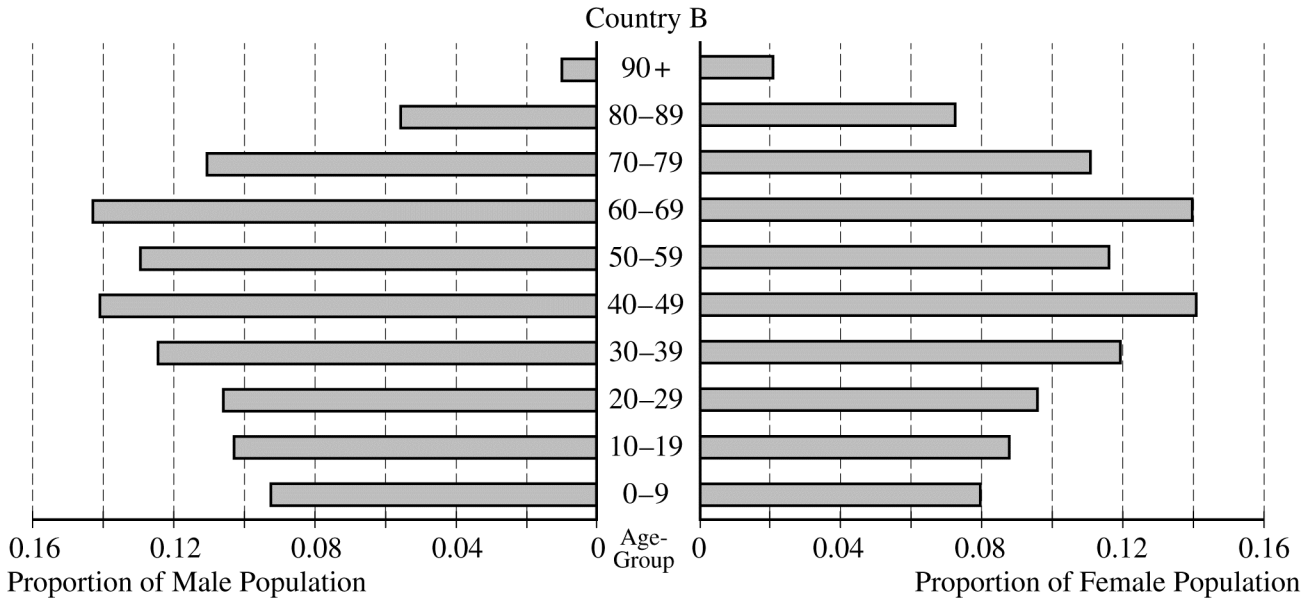
Chi-square test statistic $= \sum \dfrac{(\text{observed} - \text{expected})^2}{\text{expected}}$

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. Population pyramids are a type of bar chart that show the distribution of ages of a country's population. The distributions of ages of men and women for two countries, A and B, for the year 2015 are shown in the population pyramids below. The age-groups, in years, are listed in the center columns, and the proportions are shown on the horizontal axes. Each bar represents the proportion of the age-group in the population for that sex.





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GO ON TO THE NEXT PAGE.

(a) Is the proportion of the female population age 60 or older in Country A greater than the proportion of the female population age 60 or older in Country B? Justify your answer.

(b) One of the two countries experienced an increase in the birth rate in the years 1946 to 1955 and another increase in the birth rate about 20 years later. Based on the graphs, which country experienced the described increases in birth rate? Justify your answer using information from the graphs.

(c) For Country A, in which age-group is the median age of the male population? Justify your answer.

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2. The ability to visually search, such as when reading an x-ray or interpreting a satellite image, is an important skill in many jobs. Researchers conducted a study to investigate whether playing video games could improve a person's ability to visually search. Three video games were used in the study: one was a driving game, one was a sports game, and one was a puzzle game. The participants consisted of 60 volunteers who had no experience playing video games before the study. Each participant was randomly assigned to one of the three games so that there were 20 participants per game.

   (a) Describe an appropriate method for randomly assigning 60 participants to three groups so that each group has 20 participants.

   The time to complete a visual search task was recorded for each participant before the assigned game was played. The time to complete a visual search task was again recorded for each participant after the assigned game was played. For each game, the mean improvement time (time before minus time after) was calculated.

   (b) One researcher expressed an interest in investigating whether playing a driving game would lead to a different mean improvement time to complete a visual search task than would playing a sports game. Assuming the appropriate population values are approximately normally distributed, state the name of a test with the appropriate null and alternative hypotheses that could be used to investigate the researcher's interest.

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(c) When the appropriate test was performed, no significant difference was found in mean improvement time between the driving game and the sports game. Name one change the researchers could make in a future study to increase the power of the test. Explain why such a change would increase the power.

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3. In women's tennis, a player must win 2 out of 3 sets to win a match. If a player wins the first 2 sets, she wins the match and the third set is not played. Player V and Player M will compete in a match.

(a) Let V represent the event that Player V wins a set, and let M represent the event that Player M wins a set.

(i) List all possible sequences of events V and M by set played that will result in Player V winning the match.

(ii) List all possible sequences of events V and M by set played that will result in Player M winning the match.

Player V and Player M have competed against each other many times. Historical data show that each player is equally likely to win the first set. If Player V wins the first set, the probability that she will win the second set is 0.60. If Player V loses the first set, the probability that she will lose the second set is 0.70. If Player V wins exactly one of the first two sets, the probability that she will win the third set is 0.45.

(b) What is the probability that Player V will win a match against Player M?

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(c) What is the probability that a match between Player V and Player M will consist of 3 sets given that Player V wins the match?

(d) What is the expected number of sets played when Player V competes in a match with Player M?

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4. A sociologist was investigating the ages of grandparents of high school students. From a random sample of 10 high school students, the sociologist collected data on the current ages, in years, of the students' maternal grandparents. The data are shown in the table below.

	Student											
	A	B	C	D	E	F	G	H	I	J	Mean	Standard Deviation
Age of grandmother	75	70	55	75	55	70	80	70	74	74	69.8	8.38
Age of grandfather	74	75	65	67	60	78	83	74	70	70	71.6	6.65
Difference	1	–5	–10	8	–5	–8	–3	–4	4	4	–1.8	5.81

(a) Construct and interpret a 95 percent confidence interval for the population mean difference in age (age of grandmother minus age of grandfather) of the maternal grandparents of high school students.

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(b) One of the sociologist's research questions was about the mean difference in age without regard to which grandparent is older. The interval constructed in part (a) does not address such a question. Based on the sample of high school students, give the value of the point estimate for the mean difference in age that could be used to address the sociologist's question.

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5. An automobile manufacturer sold 30,000 new cars, one to each of 30,000 customers, in a certain year. The manufacturer was interested in investigating the proportion of the new cars that experienced a mechanical problem within the first 5,000 miles driven.

   (a) A list of the names and addresses of all customers who bought the new cars is available. Describe a sampling plan that could be used to obtain a simple random sample of 1,000 customers from the list.

Each customer from a simple random sample of 1,000 customers who bought one of the new cars was asked whether they experienced any mechanical problems within the first 5,000 miles driven. Forty customers from the sample reported a problem. Of the 40 customers who reported a problem, 13 customers, or 32.5%, reported a problem specifically with the power door locks.

   (b) Explain why 0.325 should not be used to estimate the population proportion of the 30,000 new cars sold that experienced a problem with the power door locks within the first 5,000 miles driven.

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GO ON TO THE NEXT PAGE.

(c) Based on the results of the sample, give a point estimate of the number of new cars sold that experienced a problem with the power door locks within the first 5,000 miles driven.

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GO ON TO THE NEXT PAGE.

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. Emily walks every day, and she keeps a record of the number of miles she walks each day. The histogram and five-number summary below were created from the recorded miles for a random sample of 25 of the days Emily walked.



Minimum	Q1	Median	Q3	Maximum
1.4	2.6	3.25	3.8	7.5

On one of the 25 days in the sample, Emily walked 7.5 miles. From the histogram, it appears that the value 7.5 might be an outlier relative to the other values. Two methods are proposed for identifying an outlier in a set of data.

(a) One method for identifying an outlier is to use the interquartile range (IQR). An outlier is any number that is greater than the upper quartile by at least 1.5 times the IQR or less than the lower quartile by at least 1.5 times the IQR. Does such a method identify the value of 7.5 miles as an outlier for Emily's set of data? Justify your answer.

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Another method of identifying an outlier is to investigate whether there is evidence that a value might have come from a population with a mean different from the mean of the population of the other values.

Let X and Y represent random variables. X is distributed normally with mean μ_x and standard deviation σ, and Y is distributed normally with mean μ_y and standard deviation σ. Consider 1 randomly selected value of Y and $n - 1$ randomly selected values of X.

(b) Consider the difference $Y - \overline{X}$.

(i) In terms of μ_y and μ_x, what is the mean of the difference $Y - \overline{X}$?

(ii) In terms of n and σ, what is the standard deviation of the difference $Y - \overline{X}$?

Suppose that of the $n = 25$ recorded values from Emily's sample, the value of 7.5 comes from the distribution of Y and the remaining 24 values come from the distribution of X. The summary statistics for the 24 values that come from the distribution of X are given below.

$n - 1 = 24$
$\overline{x} = 3.171$
$s = 0.821$

(c) Use the value of the potential outlier and the summary statistics of the remaining 24 values to estimate the mean and standard deviation of the difference $Y - \overline{X}$.

The estimated mean of $Y - \overline{X}$:

The estimated standard deviation of $Y - \overline{X}$:

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Recall that a method for identifying an outlier is to investigate whether there is evidence that a value might have come from a population with a mean different from the mean of the population of the other values. The following hypotheses can be used for such an investigation.

$$H_0 : \mu_y = \mu_x$$
$$H_a : \mu_y \neq \mu_x$$

(d) Calculate the value of the test statistic used for evaluating the hypotheses.

(e) The p-value for the hypothesis test described above is less than 0.0001. What conclusion can be made about the population means, and what conclusion can be made about identifying 7.5 as an outlier? Justify your answers.

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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.**

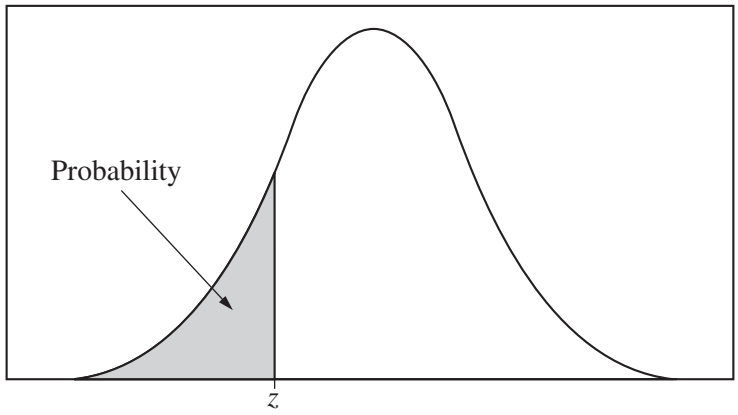

Table entry for z is the probability lying below z.

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

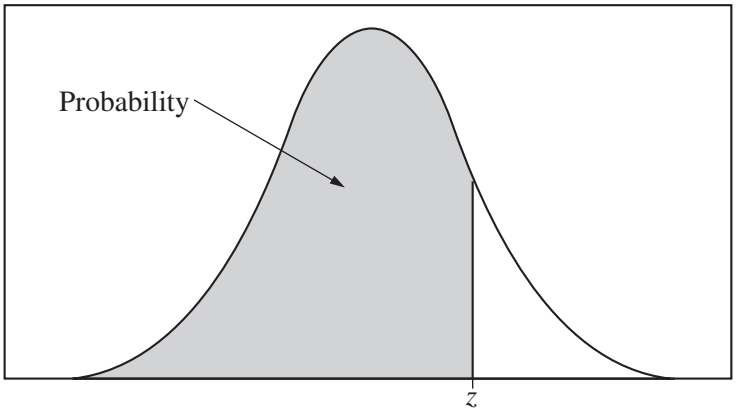

Table entry for z is the probability lying below z.

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^*.

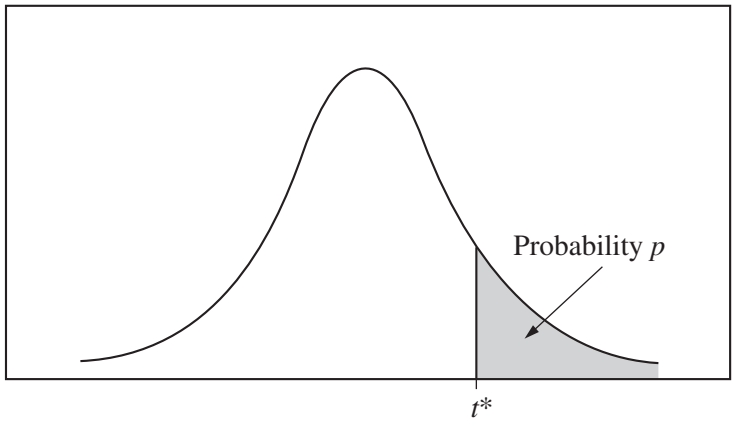

Table B ***t* distribution critical values**

	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.

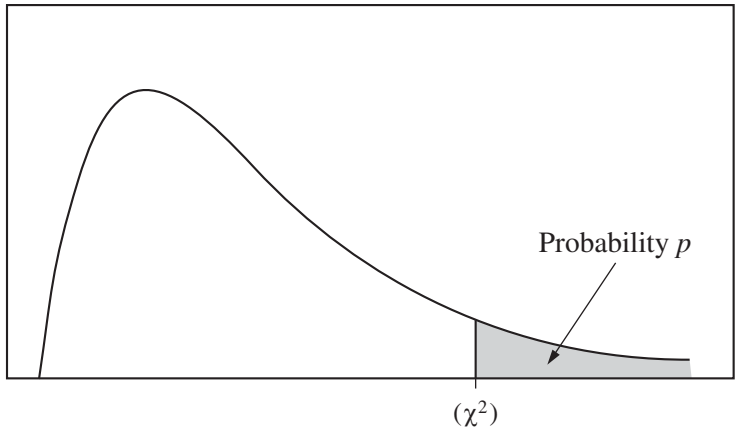

Table C χ^2 critical values

	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