From the 2018 Administration

AP CollegeBoard

AP Statistics

Practice Exam

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AP Central is the official online home for the AP Program: apcentral.collegeboard.org

Contents

Note: This publication shows the page numbers that appeared in the ***2017–18 AP Exam Instructions*** book and in the actual exam. This publication was not repaginated to begin with page 1.

Exam Instructions

The following contains instructions taken from the ***2017–18 AP Exam Instructions*** book.

AP Statistics Exam

Regularly Scheduled Exam Date: Thursday afternoon, May 17, 2018

Late-Testing Exam Date: Wednesday morning, May 23, 2018

Section I	**Total Time:** 1 hour and 30 minutes Graphing calculator expected **Number of Questions:** 40 *(The number of questions may vary slightly depending on the form of the exam.)* **Percent of Total Score:** 50% **Writing Instrument:** Pencil required
Section II	**Total Time:** 1 hour and 30 minutes Graphing calculator expected **Number of Questions:** 6 **Percent of Total Score:** 50% **Writing Instrument:** Either pencil or pen with black or dark blue ink

Before Distributing Exams: Check that the title on all exam covers is ***Statistics***. If there are any exam booklets with a different title, contact the AP coordinator immediately.

What Proctors Need to Bring to This Exam

- ☐ Exam packets
- ☐ Answer sheets
- ☐ AP Student Packs
- ☐ *2017-18 AP Coordinator's Manual*
- ☐ This book—*2017-18 AP Exam Instructions*
- ☐ AP Exam Seating Chart template
- ☐ School Code and Homeschool/Self-Study Codes
- ☐ Extra graphing calculators
- ☐ Pencil sharpener
- ☐ Container for students' electronic devices (if needed)
- ☐ Extra No. 2 pencils with erasers
- ☐ Extra pens with black or dark blue ink
- ☐ Extra paper
- ☐ Stapler
- ☐ Watch
- ☐ Signs for the door to the testing room
  - "Exam in Progress"
  - "Cell phones are prohibited during the test administration, including breaks"

Students are expected to bring graphing calculators with statistical capabilities to the AP Statistics Exam. Nongraphing scientific calculators are permitted as long as they have the required computational capabilities. Before starting the exam administration, make sure each student has a graphing calculator from the approved list on page 52 of the *2017-18 AP Coordinator's Manual* or a scientific calculator. It is up to the student to determine if a nongraphing scientific calculator has the required computational capabilities. If a student does not have a graphing calculator from the approved list or an appropriate scientific calculator, you may provide one from your supply. See pages 49–52 of the *AP Coordinator's Manual* for more information. If the student does not want to use the calculator you provide, or does not want to use a calculator at all, he or she must hand copy, date, and sign the release statement on page 51 of the *AP Coordinator's Manual*.

Students may have no more than two calculators on their desks. Calculators may not be shared. Calculator memories do not need to be cleared before or after the exam. Students with Hewlett-Packard 48–50 Series and Casio FX-9860 graphing calculators may use cards designed for use with these calculators. Proctors should make sure infrared ports (Hewlett-Packard) are not facing each other. **Since graphing calculators can be used to store data, including text, proctors should monitor that students are using their calculators appropriately. Attempts by students to use the calculator to remove exam questions and/or answers from the room may result in the cancellation of AP Exam scores.**

SECTION I: Multiple Choice

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

Make sure you begin the exam at the designated time. Remember, you must complete a seating chart for this exam. See pages 303–304 for a seating chart template and instructions. See the *2017-18 AP Coordinator's Manual* for exam seating requirements (pages 55–58).

If you are giving the regularly scheduled exam, say:
It is Thursday afternoon, May 17, and you will be taking the AP Statistics Exam.

If you are giving the alternate exam for late testing, say:
It is Wednesday morning, May 23, and you will be taking the AP Statistics Exam.

Look at your exam packet and confirm that the exam title is "AP Statistics." Raise your hand if your exam packet contains any title other than "AP Statistics," and I will help you.

Once you confirm that all students have the correct exams, say:

In a moment, you will open the exam packet. By opening this packet, you agree to all of the AP Program's policies and procedures outlined in the *2017-18 Bulletin for AP Students and Parents*.

You may now remove the shrinkwrap from your exam packet and take out the Section I booklet, but do not open the booklet or the shrinkwrapped Section II materials. Put the white seals aside. . . .

Carefully remove the AP Exam label found near the top left of your exam booklet cover. Place it on page 1 of your answer sheet on the light blue box near the top right corner that reads "AP Exam Label." . . .

If students accidentally place the exam label in the space for the number label or vice versa, advise them to leave the labels in place. They should not try to remove the label; their exam can still be processed correctly.

Listen carefully to all my instructions. I will give you time to complete each step. Please look up after completing each step. Raise your hand if you have any questions.

Give students enough time to complete each step. Don't move on until all students are ready.

Read the statements on the front cover of the Section I booklet. . . .

Sign your name, and write today's date. . . .

Now print your full legal name where indicated. . . .

Turn to the back cover of your exam booklet and read it completely. . . .

Are there any questions? . . .

You will now take the multiple-choice portion of the exam. You should have in front of you the multiple-choice booklet and your answer sheet. You may never discuss the multiple-choice exam content at any time in any form with anyone, including your teacher and other students. If you disclose the multiple-choice exam content through any means, your AP Exam score will be canceled.

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

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

Note Start Time _____. Note Stop Time _____.

Check that students are marking their answers in pencil on their answer sheets and that they are not looking at their shrinkwrapped Section II booklets. Proctors should walk around and make sure Hewlett-Packard calculators' infrared ports are not facing each other and that students are not sharing calculators.

After 1 hour and 20 minutes, say:

There are 10 minutes remaining.

After 10 minutes, say:

Stop working. Close your booklet and put your answer sheet on your desk, faceup. Make sure you have your AP number label and an AP Exam label on page 1 of your answer sheet. Sit quietly while I collect your answer sheets.

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

After all answer sheets have been collected, say:

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

Collect a Section I booklet from each student. Check that each student has signed the front cover of the sealed Section I booklet.

There is a 10-minute break between Sections I and II.

When all Section I materials have been collected and accounted for and you are ready for the break, say:

Please listen carefully to these instructions before we take a 10-minute break. All items you placed under your chair at the beginning of this exam must stay there, and you are not permitted to open or access them in any way. Leave your shrinkwrapped Section II packet on your desk during the break. You are not allowed to consult teachers, other students, notes, or textbooks during the break. You may not make phone calls, send text messages, use your calculators, check email, use a social networking site, or access any electronic or communication device. Remember, you may never discuss the multiple-choice exam content with anyone, and if you disclose the content through any means, your AP Exam score will be canceled. Are there any questions? . . .

You may begin your break. Testing will resume at _____ .

SECTION II: Free Response

After the break, say:

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

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

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

Now take an AP number label from your Student Pack and place it on the shaded box. If you don't have any AP number labels, write your AP number in the box. Look up when you have finished. . . .

Read the last statement. . . .

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

Turn to the back cover and, using your pen, complete Item 1 under "Important Identification Information." Print the first two letters of your last name and the first letter of your first name in the boxes. Look up when you have finished. . . .

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

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

Read Item 4. . . .

Are there any questions? . . .

If this is your last AP Exam, you may keep your Student Pack. Place it under your chair for now. Otherwise I will collect all Student Packs. . . .

Read the information on the back cover of the exam booklet. Do not open the booklet until you are told to do so. Look up when you have finished. . . .

Collect the Student Packs.

Then say:

Are there any questions? . . .

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

You may begin Section II.

Note Start Time _____ . **Note Stop Time** _____ .

You should also make sure that Hewlett-Packard calculators' infrared ports are not facing each other and that students are not sharing calculators.

After 1 hour and 5 minutes, say:

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

After 15 minutes, say:

There are 10 minutes remaining.

After 10 minutes, say:

Stop working and close your exam booklet. Place it on your desk, faceup. . . .

If any students used extra paper for a question in the free-response section, have those students staple the extra sheet(s) to the first page corresponding to that question in their exam booklets. Complete an Incident Report after the exam (see page 67 of the *2017-18 AP Coordinator's Manual* for complete details).

Then say:

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

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

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

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

If you are giving the regularly scheduled exam, say:
You may not discuss or share the free-response exam content with anyone unless it is released on the College Board website in about two days. Your AP Exam score results will be available online in July.

If you are giving the alternate exam for late testing, say:
None of the content in this exam may ever be discussed or shared in any way at any time. Your AP Exam score results will be available online in July.

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

Please remember to take your AP number card with you. You will need the information on this card to view your scores and order AP score reporting services online.

Then say:

You are now dismissed.

After-Exam Tasks

Be sure to give the completed seating chart to the AP coordinator. Schools must retain seating charts for at least six months (unless the state or district requires that they be retained for a longer period of time). Schools should not return any seating charts in their exam shipments unless they are required as part of an Incident Report.

NOTE: If you administered exams to students with accommodations, review the *2017-18 AP Coordinator's Manual* and the *2017-18 AP SSD Guidelines* for information about completing the NAR form, and returning these exams.

The exam proctor should complete the following tasks if asked to do so by the AP coordinator. Otherwise, the AP coordinator must complete these tasks:

- Complete an Incident Report for any students who used extra paper for the free-response section. (Incident Report forms are provided in the coordinator packets sent with the exam shipments.) **These forms must be completed with a No. 2 pencil.** It is best to complete a single Incident Report for multiple students per exam subject, per administration (regular or late testing), as long as all required information is provided. Include all exam booklets with extra sheets of paper in an Incident Report return envelope (see page 67 of the *2017-18 AP Coordinator's Manual* for complete details).
- Return all exam materials to secure storage until they are shipped back to the AP Program. (See page 26 of the *2017-18 AP Coordinator's Manual* for more information about secure storage.) Before storing materials, check the "School Use Only" section on page 1 of the answer sheet and:
  - Fill in the appropriate section number circle in order to access a separate AP Instructional Planning Report (for regularly scheduled exams only) or subject score roster at the class section or teacher level. See "Post-Exam Activities" in the *2017-18 AP Coordinator's Manual*.
  - Check your list of students who are eligible for fee reductions and fill in the appropriate circle on their registration answer sheets.

Student Answer Sheet for the Multiple-Choice Section

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

CollegeBoard AP

Answer Sheet 2018

AP Number Label
(from Student Pack)

AP FPO X123456789 X

AP Exam Label
(from Section I Booklet)

COMPLETE THIS AREA AT EVERY EXAM. **USE NO. 2 PENCIL ONLY**

I am aware of and agree to follow the policies and procedures in the *2017-18 Bulletin for AP Students and Parents* to maintain the security of the exam and the validity of my AP score. I understand and accept that my exam score may be canceled if I do not follow these policies and procedures, if I disregard any exam day instructions, or if my exam is administered improperly. I certify that I am the person whose information appears on this answer sheet.

A. SIGNATURE Sign your legal name as it will appear on your college applications. Date

B. LEGAL NAME Omit apostrophes, Jr., II.

Legal Last Name — First 15 Letters | Legal First Name — First 12 Letters | MI

C. YOUR AP NUMBER

D. EXAM DATE Month Day

E. EXAM START TIME AM PM

F. MULTIPLE-CHOICE BOOKLET SERIAL NUMBER S

G. ONLINE PROVIDER CODE

COMPLETE THIS AREA ONLY ONCE.

I. AREA CODE AND PHONE NUMBER

INTERNATIONAL PHONE

J. SCHOOL YOU ATTEND

SCHOOL CODE | School Name | City | State | Country

K. DATE OF BIRTH

Month (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec) Day Year

L. SOCIAL SECURITY NUMBER (Optional)

M. COLLEGE TO RECEIVE YOUR AP SCORE REPORT

COLLEGE CODE — Using the college code listed in the AP Student Pack, indicate the **ONE** college that you want to receive your AP score report.

College Name | City | State | Country

N. CURRENT GRADE LEVEL

- Not yet in 9th grade
- 9th
- 10th
- 11th
- 12th
- No longer in high school

O. STUDENT SEARCH SERVICE®

Colleges and scholarship programs may request your information to inform you of educational opportunities and financial aid.

Would you like us to supply your information?

- Yes
- No

If you don't answer and previously chose to participate in this service, we will continue providing your information.

H. AP EXAM I AM TAKING USING THIS ANSWER SHEET Exam Name: Form: Form Code:

801356

SCHOOL USE ONLY

Section Number: 1 2 3 4 5 6 7 8 9

Fee Reduction Granted: 1 Option 1 2 Option 2

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COMPLETE THIS AREA AT EACH EXAM (IF APPLICABLE).

P. SURVEY QUESTIONS — Answer the survey questions in the AP Student Pack. Do not put responses to exam questions in this section.

1	A B C D E F G H I	4	A B C D E F G H I	7	A B C D E F G H I
2	A B C D E F G H I	5	A B C D E F G H I	8	A B C D E F G H I
3	A B C D E F G H I	6	A B C D E F G H I	9	A B C D E F G H I

Q. LANGUAGE — Do not complete this section unless instructed to do so.

If this answer sheet is for the French Language and Culture, German Language and Culture, Italian Language and Culture, Spanish Language and Culture, or Spanish Literature and Culture Exam, please answer the following questions. Your responses will not affect your score.

1. Have you lived or studied for one month or more in a country where the language of the exam you are now taking is spoken?

○ Yes ○ No

2. Do you regularly speak or hear the language at home?

○ Yes ○ No

QUESTIONS 1–75

Indicate your answers to the exam questions in this section (pages 2 and 3). Mark only one response per question for Questions 1 through 120. If a question has only four answer options, do not mark option E. Answers written in the multiple-choice booklet will not be scored.

COMPLETE MARK ● EXAMPLES OF INCOMPLETE MARKS 

You must use a No. 2 pencil and marks must be complete. Do not use a mechanical pencil. It is very important that you fill in the entire circle darkly and completely. If you change your response, erase as completely as possible. Incomplete marks or erasures may affect your score.

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

FOR OFFICIAL USE ONLY

Exam		0	1	2	3	4	5	6	7	8	9
		0	1	2	3	4	5	6	7	8	9
Exam		0	1	2	3	4	5	6	7	8	9
		0	1	2	3	4	5	6	7	8	9

SELECTED MEDIA EXAMS	R	W	O	OTHER EXAMS	R	W	O
PT02				TOTAL			
PT03				Subscore (if applicable)			
PT04				Subscore (if applicable)			

DO NOT WRITE IN THIS AREA

QUESTIONS 76–120

Be sure each mark is dark and completely fills the circle. If a question has only four answer options, do not mark option E.

76	A B C D E	91	A B C D E	106	A B C D E
77	A B C D E	92	A B C D E	107	A B C D E
78	A B C D E	93	A B C D E	108	A B C D E
79	A B C D E	94	A B C D E	109	A B C D E
80	A B C D E	95	A B C D E	110	A B C D E
81	A B C D E	96	A B C D E	111	A B C D E
82	A B C D E	97	A B C D E	112	A B C D E
83	A B C D E	98	A B C D E	113	A B C D E
84	A B C D E	99	A B C D E	114	A B C D E
85	A B C D E	100	A B C D E	115	A B C D E
86	A B C D E	101	A B C D E	116	A B C D E
87	A B C D E	102	A B C D E	117	A B C D E
88	A B C D E	103	A B C D E	118	A B C D E
89	A B C D E	104	A B C D E	119	A B C D E
90	A B C D E	105	A B C D E	120	A B C D E

QUESTIONS 121–126

For Students Taking AP Biology

Write your answer in the boxes at the top of the griddable area and fill in the corresponding circles. Mark only one circle in any column. You will receive credit only if the circles are filled in correctly.

121 122 123 124 125 126

QUESTIONS 131–142

For Students Taking AP Computer Science Principles, AP Physics 1, or AP Physics 2

Mark two responses per question. You will receive credit only if both correct responses are selected.

131	A B C D	135	A B C D	139	A B C D
132	A B C D	136	A B C D	140	A B C D
133	A B C D	137	A B C D	141	A B C D
134	A B C D	138	A B C D	142	A B C D

DO NOT WRITE IN THIS AREA

COMPLETE THIS AREA ONLY ONCE.

R. YOUR MAILING ADDRESS

Use the address abbreviations from your AP Student Pack. Fill in only one circle per column. Indicate a space in your address by leaving a blank box; do not grid that column.

STREET ADDRESS (include street number, street name, apartment number, etc.)

CITY

ZIP OR POSTAL CODE

COUNTRY CODE

STATE

AK	HI	MI	NY	VT	
AL	IA	MN	OH	WA	
AR	ID	MO	OK	WI	
AZ	IL	MS	OR	WV	
CA	IN	MT	PA	WY	
CO	KS	NC	RI	Puerto Rico	
CT	KY	ND	SC		
DC	LA	NE	SD	AA	
DE	MA	NH	TN	AE	
FL	MD	NJ	TX	AP	
GA	ME	NM	UT	Other	
		NV	VA		

V. SEX

- Female
- Male

W. WHICH LANGUAGE DO YOU KNOW BEST?

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

X. RACIAL/ETHNIC GROUP

Please answer both questions about Hispanic origin and about race. For the following questions about your identity, Hispanic origins are not races.

(You may mark all that apply.)

a. Are you of Hispanic, Latino, or Spanish origin?

- No, not of Hispanic, Latino, or Spanish origin
- Yes, Cuban
- Yes, Mexican
- Yes, Puerto Rican
- Yes, another Hispanic, Latino, or Spanish origin

b. What is your race?

- American Indian or Alaska Native
- Asian (including Indian subcontinent and Philippines origin)
- Black or African American (including Africa and Afro-Caribbean origin)
- Native Hawaiian or other Pacific Islander
- White (including Middle Eastern origin)

Y. PARENTAL EDUCATION LEVEL

In the first column, indicate the highest level of education of one parent/guardian, and indicate whether this is your mother/female guardian or father/male guardian. Then, if applicable, indicate the highest level of education of your other parent/guardian in the second column, and indicate whether this is your mother/female guardian or father/male guardian.

Mother or female guardian	
Father or male guardian	
Grade school	Grade school
Some high school	Some high school
High school diploma or equivalent	High school diploma or equivalent
Vocational or trade school	Vocational or trade school
Some college	Some college
Associate or two-year degree	Associate or two-year degree
Bachelor's or four-year degree	Bachelor's or four-year degree
Some graduate or professional school	Some graduate or professional school
Graduate or professional degree	Graduate or professional degree

S. FOR STUDENTS OUTSIDE THE UNITED STATES ONLY

If your address does not fit in the spaces provided in Item R, fill in as many circles as you can, then fill in the circle in Item S and print the remainder of your address in the spaces provided.

Address	City	State or Province	Country	ZIP or Postal Code

T. STUDENT IDENTIFIER (Student ID Number)

U. EMAIL ADDRESS

By providing your email address, you are granting the College Board permission to use your email address in accordance with the policies in the *2017-18 Bulletin for AP Students and Parents*.

Section I: Multiple-Choice Questions

This is the multiple-choice section of the 2018 AP Exam.
It includes cover material and other administrative instructions
to help familiarize students with the mechanics of the exam.
(Note that future exams may differ in look from the following content.)

AP® 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

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

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

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

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

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

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

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

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

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

(II) Probability

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

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

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

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

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

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

$$\mu_X = np$$

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

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

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

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

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

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

(III) Inferential Statistics

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

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

Single-Sample

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

Two-Sample

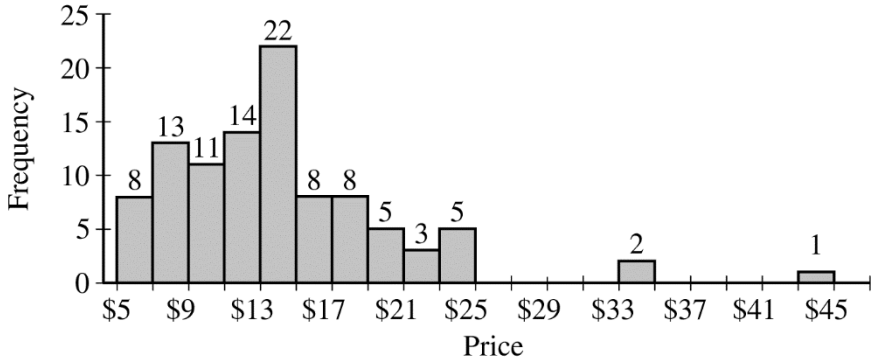
Statistic	Standard Deviation of Statistic
Difference of sample means	$\sqrt{\dfrac{\sigma_1^2}{n_1} + \dfrac{\sigma_2^2}{n_2}}$ Special case when $\sigma_1 = \sigma_2$ $\sigma\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}$
Difference of sample proportions	$\sqrt{\dfrac{p_1(1-p_1)}{n_1} + \dfrac{p_2(1-p_2)}{n_2}}$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

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

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

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

1. The 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

GO ON TO THE NEXT PAGE.

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

GO ON TO THE NEXT PAGE.

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.

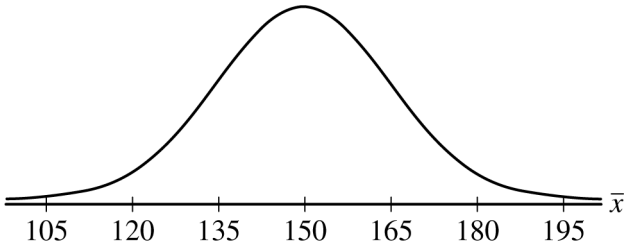
   (B) Randomly select 50 students on the list.

   (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.

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 σ_x.



Sampling Distribution of $\bar{x}$

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

(A) 3

(B) 6

(C) 15

(D) 30

(E) 75

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.

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

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

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

---

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

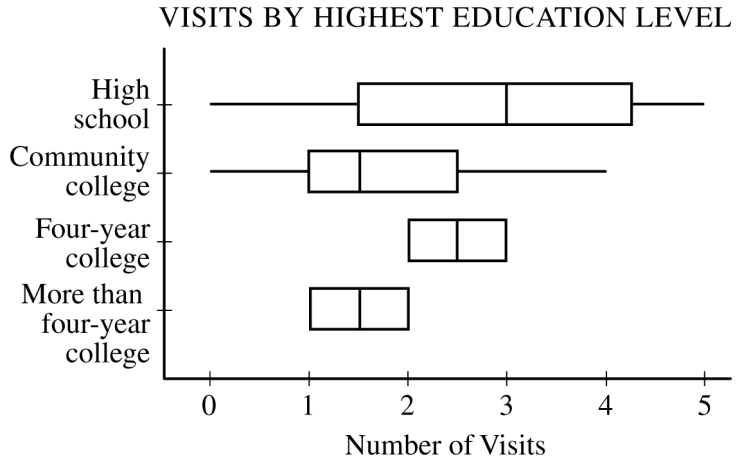
(B) 0.331

(C) 0.558

(D) 0.669

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

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.

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

---

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

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

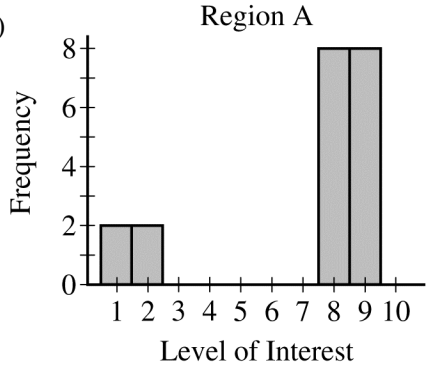
(C) An observational study using a simple random sample

(D) An observational study using a cluster sample

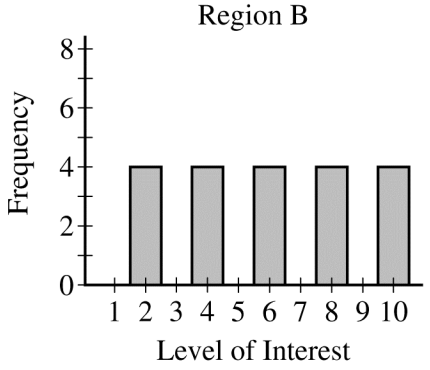
(E) An observational study using a stratified sample

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?

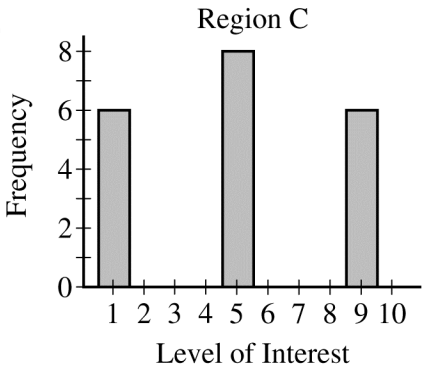
(A)



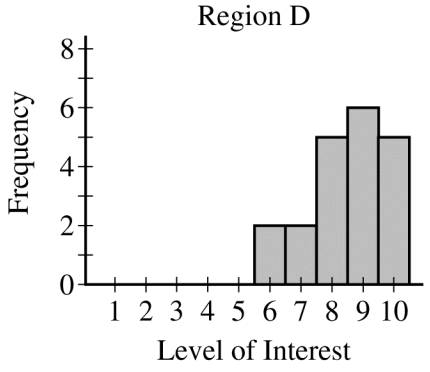
(B)



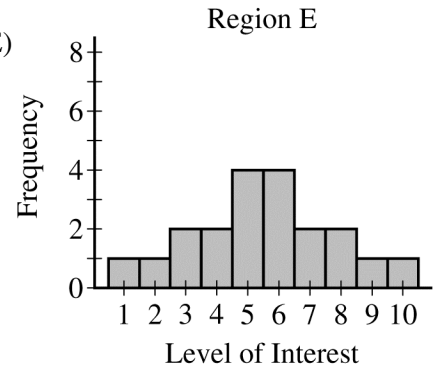
(C)



(D)



(E)



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

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

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.

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

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)

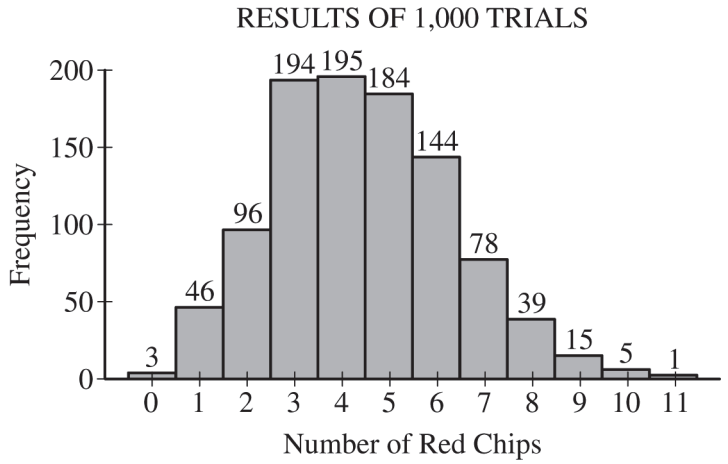
21. For a school fund-raiser, 600 raffle tickets were sold by students at the school, of which 88 were sold by one student, Audrey. Of the 600 tickets sold, 30 were randomly selected to receive prizes, and 7 of the 30 tickets selected were tickets sold by Audrey. To investigate how likely it was by chance 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.

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

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.

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%

---

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.

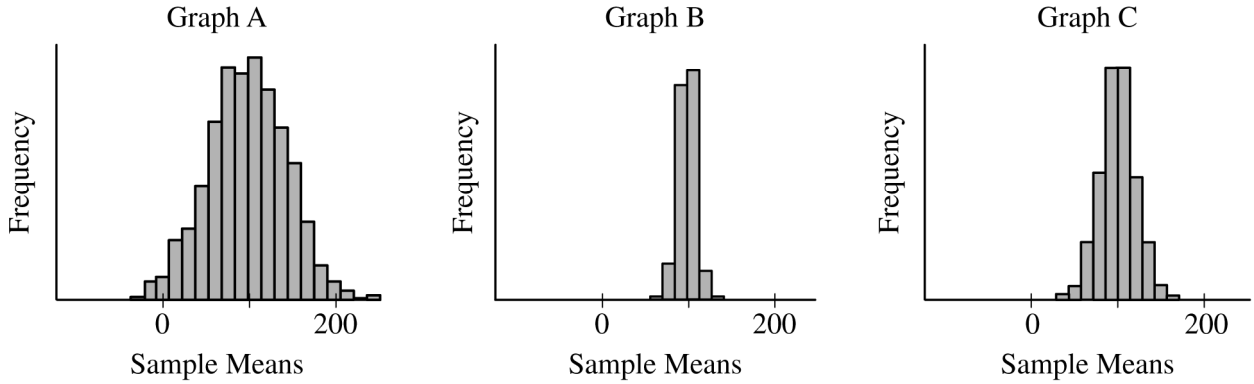
(C) Yes, because the *p*-value of 0.064 is greater than the significance level of 0.05.

(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.

GO ON TO THE NEXT PAGE.

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

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.

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

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.

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

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%.

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.

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

GO ON TO THE NEXT PAGE.

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.

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

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) $1.882 \pm 2.262(6.6854)$

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

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

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.

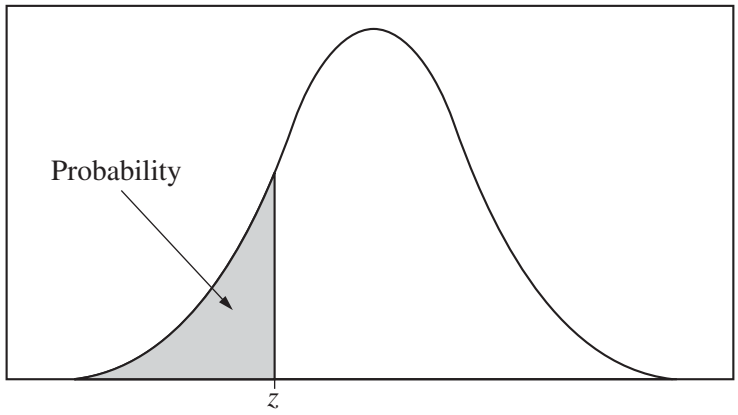


Table A Standard normal probabilities

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.

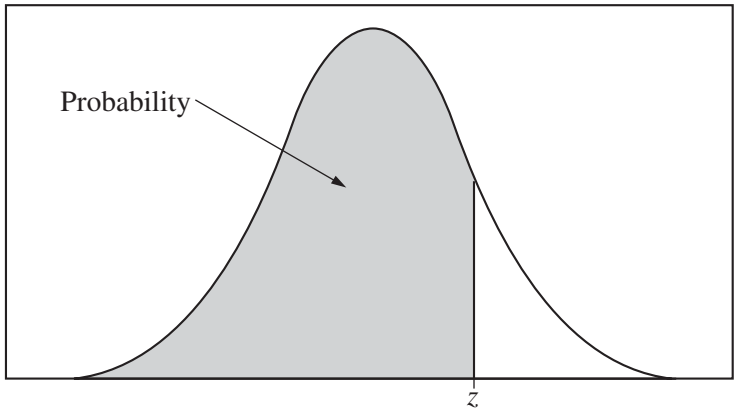


Table A (*Continued*)

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^*.

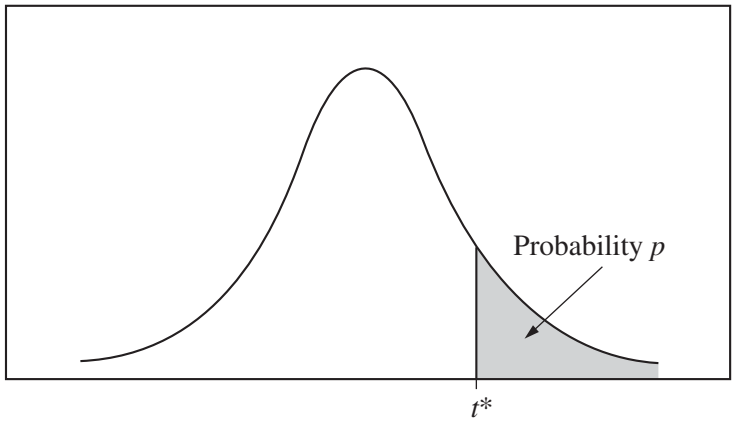


Table B ***t* distribution critical values**

	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.

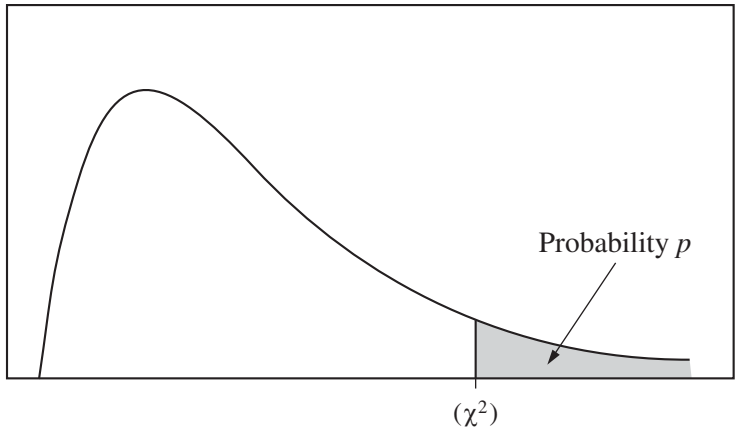


Table C χ^2 critical values

	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

Section II: Free-Response Questions

This is the free-response section of the 2018 AP Exam.
It includes cover material and other administrative instructions
to help familiarize students with the mechanics of the exam.
(Note that future exams may differ in look from the following content.)

AP® 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

(I) Descriptive Statistics

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

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

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

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

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

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

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

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

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

(II) Probability

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

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

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

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

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

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

$$\mu_X = np$$

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

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

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

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

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

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

(III) Inferential Statistics

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

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

Single-Sample

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

Two-Sample

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

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

STATISTICS

SECTION II

Part A

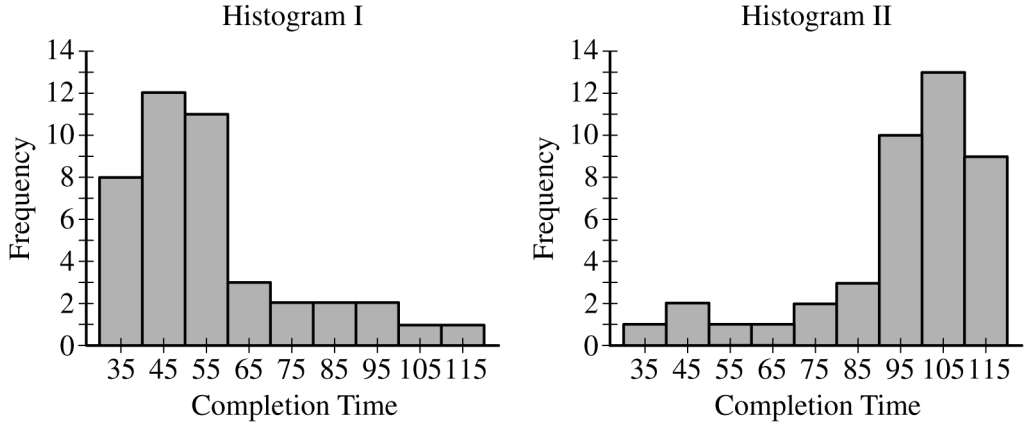
Questions 1-5

Spend about 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.

GO ON TO THE NEXT PAGE.

(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.

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?

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

GO ON TO THE NEXT PAGE.

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?

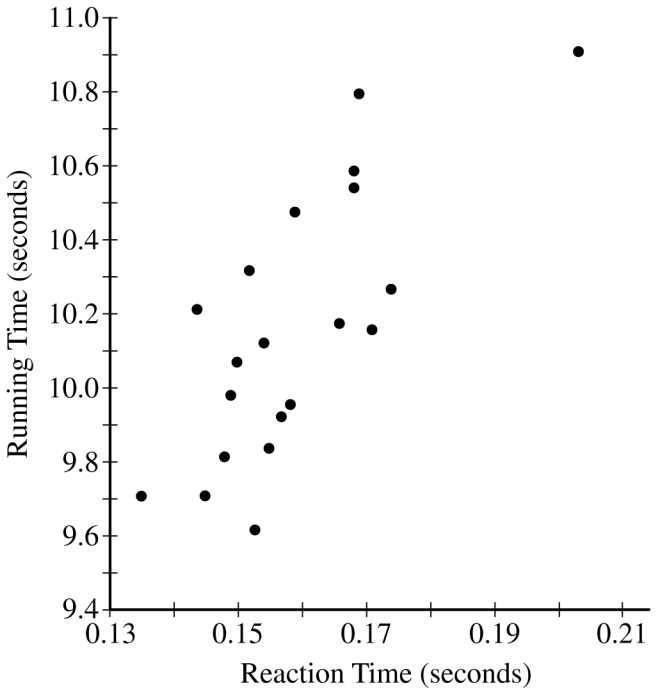
(c) Suppose a stratified random sampling design is used to select a sample of 30 women who do not meet the age requirement and a sample of 70 women who do meet the age requirement. Based on the probability distribution, is a woman who does not meet the age requirement more likely, less likely, or equally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

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.

(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.

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.

(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.

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.

(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 $\hat{D}$.

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.

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.**

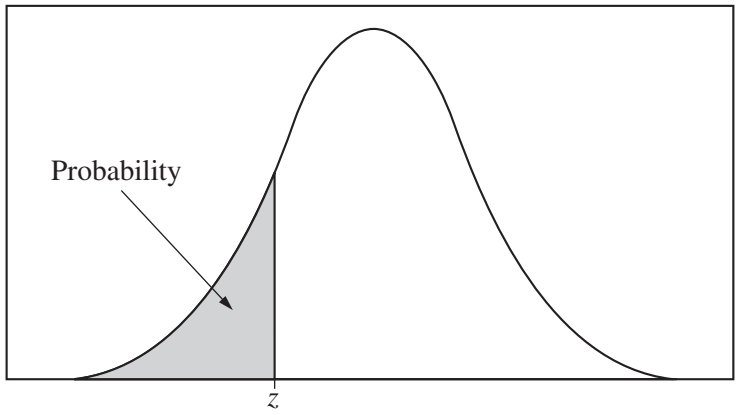


Table entry for z is the probability lying below z.

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

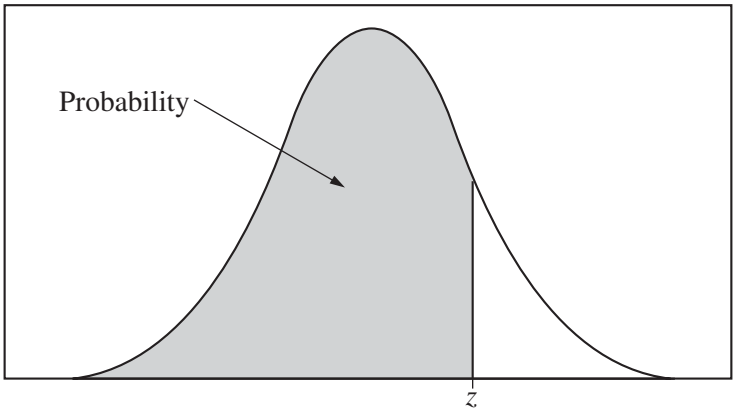


Table entry for z is the probability lying below z.

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^*.

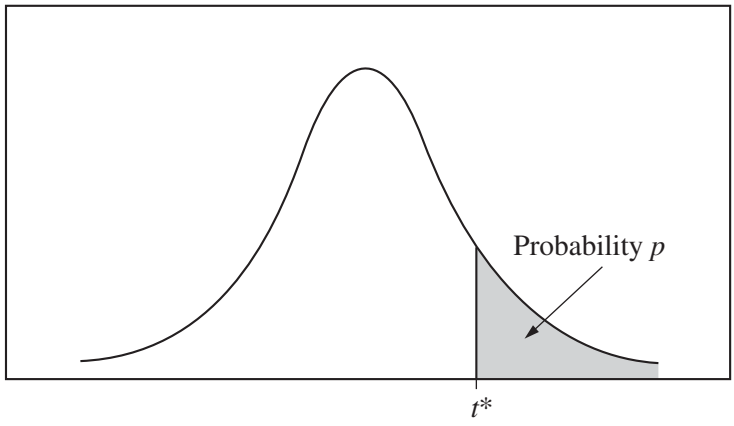


Table B ***t* distribution critical values**

	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.

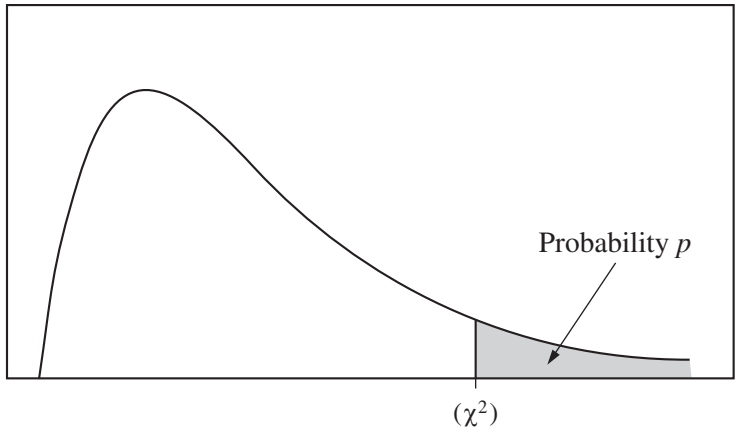


Table C χ^2 critical values

	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

Multiple-Choice Answer Key

The following contains the answers to
the multiple-choice questions in this exam.

Answer Key for AP Statistics
Practice Exam, Section I

Question 1: D
Question 2: E
Question 3: D
Question 4: D
Question 5: E
Question 6: B
Question 7: C
Question 8: E
Question 9: C
Question 10: E
Question 11: C
Question 12: C
Question 13: C
Question 14: A
Question 15: D
Question 16: B
Question 17: A
Question 18: B
Question 19: A
Question 20: C
Question 21: E
Question 22: D
Question 23: D
Question 24: A
Question 25: C
Question 26: B
Question 27: A
Question 28: C
Question 29: E
Question 30: D
Question 31: A
Question 32: E
Question 33: E
Question 34: D
Question 35: A
Question 36: B
Question 37: B
Question 38: B
Question 39: B
Question 40: B

Free-Response Scoring Guidelines

The following contains the scoring guidelines
for the free-response questions in this exam.

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Question 1

Intent of Question

The primary goals of this question are to assess a student's ability to (1) identify which one of two histograms is more likely to represent the data from a particular situation; (2) describe the distribution of a quantitative variable based on a histogram that would result from combining two separate histograms; and (3) describe a sampling distribution of the mean when provided with a population mean, population standard deviation, sample size and shape of the population.

Solution

Part (a):

Histogram II is more likely to represent the Group R completion times. As noted, students in Group S typically took less time to complete the task, and although the two histograms show the same range, the values in Histogram I are generally smaller than those in Histogram II. So Histogram I is likely to represent students in Group S and Histogram II is likely to represent students in Group R.

Part (b):

If the two histograms were to be combined, the distribution of completion times would be bimodal. All values would be in the interval from 35 to 115. There would be more completion times in the intervals from 35 to 55 and 95 to 115 than in the middle interval of 65 to 85.

Part (c):

The sampling distribution of the sample mean will be approximately normal with mean $\mu_{\bar{x}} = 70$ minutes and standard deviation $\sigma_{\bar{x}} = \frac{26.5}{\sqrt{50}} = 3.75$ minutes. Although the original distribution of completion times is bimodal, the Central Limit theorem applies in this situation because the sample size of 50 is fairly large, especially because there are no major outliers or skewness. Therefore, the sampling distribution is approximately normal.

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Question 1 (continued)

Scoring

Parts (a), (b) and (c) are each scored as essentially correct (E), partially correct (P), or incorrect (I).

Part (a) is scored as follows:

Essentially correct (E) if the response correctly provides the following three components:

1. States that Histogram II is more likely to be Group R.
2. Refers to the fact that Group R should have longer completion times (or Group S should have shorter completion times).
3. Justifies the choice based on a comparison of the locations of the peaks or of the ranges in Histograms I and II.

Partially correct (P) if the response provides component 1 and one of the other two components required for E.

Incorrect if the response does not meet the criteria for E or P.

Note: Labeling Histogram II as being "Group R" is sufficient to satisfy the requirement of stating that Histogram II is more likely to be Group R.

Part (b) is scored as follows:

Essentially correct (E) if the response states that the shape would be bimodal AND provides a reasonable description of the distinct nature of the peaks. Examples of reasonable descriptions include drawing a picture showing the approximate heights of the bars in each interval, or noting that the distribution will have a distinct peak on each side.

Partially correct (P) if the response simply states that the shape is bimodal, without sufficient explanation;
OR
if the response provides a description or drawing illustrating the bimodal shape, but never uses the term "bimodal."

Incorrect (I) if the response does not meet the criteria for E or P.

Note: The question asks about the shape of the histogram, so any computations or reference to center and spread can be ignored, whether they are correct or incorrect.

Question 1 (continued)

Part (c) is scored as follows:

Essentially correct (E) if the response correctly provides the following four components:

1. States that the mean of the sampling distribution is 70 minutes.
2. Correctly calculates the standard deviation of the sampling distribution as 3.75 minutes, with enough work shown to know how the value was calculated.
3. States that the shape is *approximately* normal.
4. Justifies the shape by noting that the sample size of 50 is large.

Partially correct (P) if the response correctly provides only two or three of the four components required for E.

Incorrect (I) if the student provides at most one of the components required for E.

Notes

- Describing the sampling distribution as *normal* instead of *approximately* normal does not satisfy component 3.
- Component 2 is satisfied if the formula $\frac{26.5}{\sqrt{50}}$ is shown but the computation showing 3.75 as the answer is not performed.
- Context ("minutes") is not required to satisfy components 1 and 2.

Question 1 (continued)

4 Complete Response

Three parts essentially correct

3 Substantial Response

Two parts essentially correct and one part partially correct

2 Developing Response

Two parts essentially correct and no parts partially correct

OR

One part essentially correct and one or two parts partially correct

OR

Three parts partially correct

1 Minimal Response

One part essentially correct

OR

No parts essentially correct and two parts partially correct

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Question 2

Intent of Question

The primary goals of this question are to assess a student's ability to (1) explain why blocking is used in an experiment; (2) explain why random assignment of treatments is used in an experiment; and (3) explain how and why replication is used in an experiment.

Solution

Part (a):

Blocking is used to account for a known source of variation in the response to allow for a more precise comparison of the treatments. In this situation the response variable is running speed. Professional runners are likely to have higher running speeds than recreational runners, so the variability in speed across runners should be smaller within each classification group than it is for all runners combined. Having smaller variability in responses makes it easier to detect a difference between the two shoe types, if it exists.

Part (b):

Randomization is used to reduce or eliminate the effect of confounding variables that might be related to the explanatory variable (shoe type, in this case) and might also be associated with differences in the response (running speed, in this case). If runners were allowed to choose which shoe to wear, it's possible that the runners who choose type A might differ in other ways from the runners who choose type B, and that those differences might be related to running speed.

Part (c):

The design addresses replication by assigning multiple runners in each classification to wear each shoe type. Replication is important in order to estimate the natural variability in running speeds within each type of runner and shoe type. The estimate of natural variability is needed so that the mean running speeds for the two types of shoes can be compared. Without an estimate of natural variability there is no way to know if the difference in mean running times for the two shoe types within each runner classification is larger than would be expected by chance.

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Question 2 (continued)

Scoring

Parts (a), (b) and (c) are each scored as essentially correct (E), partially correct (P), or incorrect (I).

Part (a) is scored as follows:

Essentially correct (E) if the response includes both of the following components:

1. A reasonable description that blocking on classification of runner accounts for a known source of variation in times, in context, and
2. A reasonable explanation of the fact that blocking on a known source of variability in the response allows for a more precise comparison of treatment groups.

Partially correct (P) if the response includes one but not both of the components required for an E.

Incorrect (I) if the response does not meet the criteria for E or P.

Part (b) is scored as follows:

Essentially correct (E) if the response includes the following two components.

1. A reasonable explanation of the fact that randomizing treatments is used to reduce or eliminate the possibility of confounding variables, and
2. A reasonable explanation of how self-selection to treatments could introduce a confounding variable, in context, by name or by example.

Partially correct (P) if the response includes one but not both of the components required for E.

Incorrect (I) if the response does not meet the criteria for E or P.

Notes:

- A response cannot earn an E if it explicitly describes random sampling.
- An explanation that randomizing treatments is necessary for a cause and effect conclusion earns credit for component (1).

Question 2 (continued)

Part (c) is scored as follows:

Essentially correct (E) if the response includes the following two components.

1. An explanation of how replication is addressed in the design that includes the fact that multiple runners are used.
2. Recognition that a benefit of replication is to obtain an estimate of variability in the response.

Partially correct (P) if the response includes one but not both of the components required for E.

Incorrect (I) if the response does not meet the criteria for E or P.

Notes:

- An explanation that a benefit of replication is to enable a statistical comparison of treatments earns credit for component (2).
- An explanation that larger sample sizes increase the precision of comparisons earns credit for component (2).
- If the response does not earn credit for component (1), an explanation of a statistical benefit of replication which is tied to component (1) (e.g., the benefit of repeated measurement on the same individual, or the benefit of using both professional and recreational runners) can earn credit for component (2).

Question 2 (continued)

4 Complete Response

Three parts essentially correct

3 Substantial Response

Two parts essentially correct and one part partially correct

2 Developing Response

Two parts essentially correct and no parts partially correct

OR

One part essentially correct and one or two parts partially correct

OR

Three parts partially correct

1 Minimal Response

One part essentially correct

OR

No parts essentially correct and two parts partially correct

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Question 3

Intent of Question

The primary goals of this question are to assess a student's ability to (1) find probabilities for a discrete random variable using a probability distribution presented in table form; (2) recognize a binomial random variable and compute a cumulative probability for it; and (3) compare the likelihoods of a particular event based on whether a simple random sample or a stratified random sample is selected.

Solution

Part (a):

The selected woman will not meet the age requirement if she is 17, 18 or 19 years old. Therefore, the probability that the selected woman will not meet the age requirement is $0.005 + 0.107 + 0.111 = 0.223$.

Part (b):

Let X represent the number of women in the sample who do not meet the age requirement. X is a binomial random variable with $n = 100$ and $p = 0.223$, as found in part (a). At least 30% of the sample will not meet the age requirement if $X \geq 30$. Using an exact binomial probability gives $P(X \geq 30) = 1 - P(X \leq 29) = 1 - 0.9547 = 0.0453$.

Part (c):

As shown in part (a), the proportion of women in the population who do not meet the age requirement is 0.223. With a simple random sample of 100, the expected percent who do not meet the age requirement is 22.3%. But with the stratified sample, the actual percent who do not meet the age requirement is set at 30%. Therefore, a woman who does not meet the age requirement is more likely to make it into the stratified sample than the simple random sample.

Scoring

Parts (a), (b) and (c) are scored as essentially correct (E), partially correct (P), or incorrect (I).

Part (a) is scored as follows:

Essentially correct (E) if the probability is computed correctly with work shown.

Partially correct (P) if the correct answer is given but no work is shown;
OR
if the correct probabilities are used to find the answer to a different related question, such as the probability that the woman will be at least 20 years old, or exactly 20 years old.

Incorrect (I) if no reasonable probability for answering the question is calculated.

AP® STATISTICS
2018 SCORING GUIDELINES

Question 3 (continued)

Part (b) is scored as follows:

Essentially correct (E) if the response includes the following three components.

1. States that the number of women in the sample who do not meet the age requirement is a binomial random variable or specifies the correct values for n and p.
2. Provides the correct answer using either an exact binomial calculation, or a normal approximation to the binomial.
3. Shows sufficient work to understand how the answer was calculated.

Partially correct (P) if the response includes two of the three components required for E.

Incorrect if the response does not meet the criteria for E or P.

Notes:

- The correct value of p can either be recomputed in part (b) or defined as whatever value the response in part (a) reported for the probability that a randomly selected woman will not meet the age requirement.
- Component 3 can be satisfied using calculator notation as long as n, p, and X are labeled.

Part (c) is scored as follows:

Essentially correct (E) if the response includes the following two components:

1. Correctly states that a woman who does not meet the age requirement is more likely to be included in the stratified random sample than with the simple random sample
2. Justifies the choice by comparing the expected percentage of women who do not meet the age requirement for the simple random sample (22.3%) with the percentage for the stratified random sample (30%).

Partially correct (P) if the response:

1. Correctly states that a woman who does not meet the age requirement is more likely to be included in the stratified random sample than with the simple random sample, *AND*
2. Provides only a weak justification, such as correctly mentioning one percentage, but not both.

Incorrect if the response does not meet the criteria for E or P.

Note: Component 2 is satisfied by comparing the expected counts (as opposed to percentages) for the two sampling methods.

Question 3 (continued)

4 Complete Response

Three parts essentially correct

3 Substantial Response

Two parts essentially correct and one part partially correct

2 Developing Response

Two parts essentially correct and no parts partially correct

OR

One part essentially correct and one or two parts partially correct

OR

Three parts partially correct

1 Minimal Response

One part essentially correct

OR

No parts essentially correct and two parts partially correct

AP® STATISTICS
2018 SCORING GUIDELINES

Question 4

Intent of Question

The primary goals of this question are to assess a student's ability to (1) identify and compute an appropriate confidence interval after checking the necessary conditions, (2) interpret the confidence interval in context, and (3) determine whether it is appropriate to use the interval to answer a question about an individual.

Solution

Part (a):

Step 1: Identify the appropriate confidence interval (by name or formula) and check appropriate conditions.

The appropriate procedure is a one-sample *t*-interval for a population mean.

Conditions: 1. The sample is randomly selected from the population.
2. The population has a normal distribution, or the sample size is large.

Condition 1 is met because the stem states that a random sample was selected.
Condition 2 is met because the sample size of 61 is greater than 30.

Step 2: Correct mechanics

A confidence interval for the population mean is given by $\bar{x} \pm t^* \frac{s}{\sqrt{n}}$. The critical value for 99% confidence, based on $61-1=60$ degrees of freedom, is $t^* = 2.660$. The 99% confidence interval for the population mean number of steps taken per workday is

$$9{,}797 \pm 2.66\left(\frac{2{,}313}{\sqrt{61}}\right) = 9{,}797 \pm 787.76, \text{ or}$$

9,009.24 to 10,584.76, or

9,009 steps to 10,585 steps, rounded.

Step 3: Interpretation

We can be 99% confident that for the population of people working in New York City who wear fitness trackers the mean number of steps taken per workday is between 9,009 and 10,585.

Part (b):

No, it is not appropriate. A confidence interval provides an estimate of the population mean value, but does not provide information about the range of individual values.

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2018 SCORING GUIDELINES

Question 4 (continued)

Scoring

The question is scored in four sections. Section 1 consist of part (a), step 1; section 2 consists of part (a), step 2; section 3 consists of part (a), step 3 and section 4 consists of part (b). Each section is scored as essentially correct (E), partially correct (P), or incorrect (I).

Section 1 is scored as follows:

Essentially correct (E) if the response includes all three of the following components:
1. Identifies a one-sample *t*-interval (either by name or by formula).
2. States that random sampling is a required condition for inference and explains how the condition is satisfied.
3. States that either the population distribution must be normal or the sample size must be large and justifies that the condition is satisfied.

Partially correct (P) if the response includes component (1) and one of the two remaining components required for an E.

Incorrect (I) if the response does not meet the criteria for E or P.

Note: Component (1) cannot be satisfied by a formula that uses incorrect statistical notation, such as μ or σ, instead of $\bar{x}$ or s.

Section 2 is scored as follows:

Essentially correct (E) if the response gives the correct confidence interval. Supporting work is not required, but if included, it must be correct.

Partially correct (P) if the response has the correct interval with an error in the supporting work;
OR
the response has an incorrect interval resulting from one or more errors in the supporting work shown. Examples of possible errors include: using the *t* multiplier for a 95% confidence interval, or using the wrong degrees of freedom for the multiplier for a 99% confidence interval, or dividing by $\sqrt{60}$ instead of $\sqrt{61}$.

Incorrect if the response does not meet the criteria for E or P.

Notes:
- A minor arithmetic error or transcription error, such as writing 9,779 instead of 9,797 or 2,331 instead of 2,313, does not reduce the score from E to P or P to I.
- Providing the appropriate formula for the *t*-interval using μ or σ, instead of $\bar{x}$ or s does not reduce the score from E to P or P to I.

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2018 SCORING GUIDELINES

Question 4 (continued)

Section 3 is scored as follows:

Essentially correct (E) if the response gives a reasonable interpretation of the interval that includes the following four components.

1. 99% confidence interval statement
2. Estimate is for a mean
3. Inference is about a population
4. Context ("number of steps" is sufficient for context)

Partially correct (P) if the response gives a reasonable interpretation of the interval that includes component (1) AND two of the remaining three components required for an (E);

OR

if the response gives a correct interpretation of the confidence level in context but does not attempt to interpret the confidence interval.

Incorrect (I) if the response does not meet the criteria for E or P.

Note: If a 95% confidence interval is constructed in section 2, then the interpretation in section 3 is scored as essentially correct if component (1) is stated as 95% confidence and the other components are all correct.

Section 4 is scored as follows:

Essentially correct (E) if the response in part (b) correctly notes that the interval cannot be used to conduct the investigation *AND* gives a justification that illustrates understanding that confidence intervals are not about individual values.

Note: Examples of acceptable justification include noting that an individual value could be investigated by constructing an interval using the sample mean and standard deviation only, or constructing such an interval, or computing a *z*-score using the sample mean and standard deviation only.

Partially correct (P) if the response correctly notes that it is not appropriate to use the interval, with weak, but reasonable justification.

Note: An example of an unreasonable justification is explaining that 8,500 is unusual (i.e., an outlier) because it lies outside of the interval in part (a).

Incorrect (I) if the response does not meet the criteria for E or P.

Question 4 (continued)

Each essentially correct (E) section counts as 1 point, and a partially correct (P) section counts as ½ point.

4 **Complete Response**

3 **Substantial Response**

2 **Developing Response**

1 **Minimal Response**

If a response is between two scores (for example, 2½ points), use a holistic approach to decide whether to score up or down, depending on the strength of the response and communication.

AP® STATISTICS
2018 SCORING GUIDELINES

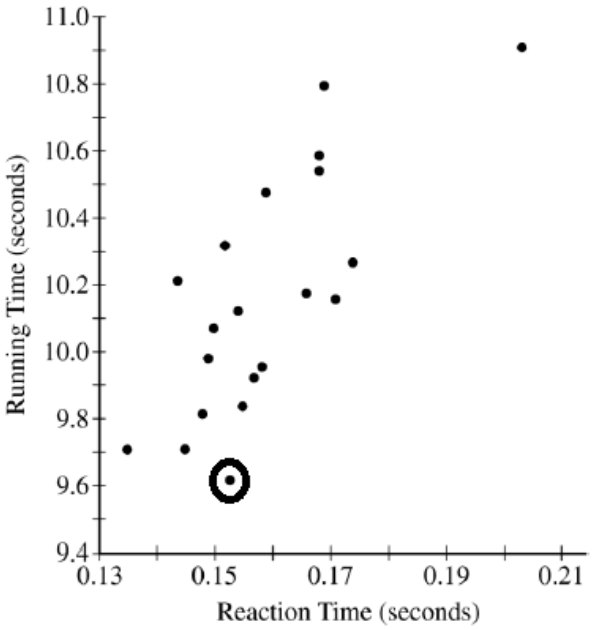
Question 5

Intent of Question

The primary goals of this question are to assess a student's ability to (1) interpret information in a scatter plot; (2) assess whether two quantitative variables are independent based on a scatter plot; and (3) assess whether data illustrated in a scatter plot can be used to predict a *y*-value for an *x*-value outside the range of the data.

Solution

Part (a):



The runner who won the race would be the one with the lowest sum of the two variables, which is the runner whose reaction time was about 0.152 seconds and running time was about 9.61 seconds, for a total of about 9.762 seconds.

Part (b):

It is not reasonable to assume that reaction time and running time are independent. There is a strong linear relationship between them, illustrated by the scatter plot.

Part (c):

It might not be appropriate to predict the running time for a runner whose reaction time is 0.30 seconds because the highest observed reaction time in the graph is only about 0.202 seconds, and 0.30 seconds is substantially slower than 0.202. It also might not be appropriate to extrapolate beyond the value of 0.202 seconds because the relationship between the *x*- and *y*-variables may be different for higher reaction time values.

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2018 SCORING GUIDELINES

Question 5 (continued)

Scoring

Parts (a), (b) and (c) are each scored as essentially correct (E), partially correct (P), or incorrect (I).

Part (a) is scored as follows:

Essentially correct (E) if the response indicates the correct point on the graph and provides a good approximation for the total time of the race for that runner.

Partially correct (P) if the response chooses the wrong point, but provides a good approximation for the total time of the race for the runner chosen;
OR
if the response circles the correct point but does not provide a good approximation for the total time for that runner.

Incorrect (I) if the response does not meet the criteria for E or P.

Note: An approximation for total time that falls between 9.75 and 9.765 seconds is acceptable for part (a), even with no work shown. Due to different scales on the axes, reasonable justification must be provided for values of total time outside the interval from 9.75 and 9.765 seconds. Examples of reasonable justification include writing the approximate values for reaction time and running time, drawing relevant tick marks on the graph, or drawing relevant lines on the graph.

Part (b) is scored as follows:

Essentially correct (E) if the response says that it is not reasonable because of the presence of a clear, positive association.

Partially correct (P) if the response says that it is not reasonable but provides only a weak justification, such as “correlation” or “association”;
OR
if the response says that it *is* reasonable to assume they are independent, but then provides an explanation indicating the presence of a clear, positive association.

Incorrect if the response does not meet the criteria for E or P.

Part (c) is scored as follows:

Essentially correct (E) if the response includes the following two components
1. Notes that 0.30 is longer than the slowest reaction time shown in the graph, and
2. States that the relationship may be different outside of the range shown, or argues that the model may provide an unreasonable prediction for a reaction time of 0.3 seconds.

Partially correct (P) if the response includes only one of the two components required for E.

Incorrect if the response does not meet the criteria for E or P.

Question 5 (continued)

4 Complete Response

Three parts essentially correct

3 Substantial Response

Two parts essentially correct and one part partially correct

2 Developing Response

Two parts essentially correct and no parts partially correct

OR

One part essentially correct and one or two parts partially correct

OR

Three parts partially correct

1 Minimal Response

One part essentially correct

OR

No parts essentially correct and two parts partially correct

AP® STATISTICS
2018 SCORING GUIDELINES

Question 6

Intent of Question

The primary goals of this question are to assess a student's ability to (1) explain how to determine whether a sampling distribution is approximately normal; (2) calculate the standard error for the sampling distribution of a proportion and compare it to a value; (3) calculate the standard error for the average of two independent random variables; (4) conduct a test of hypotheses in a non-standard situation, using a rule called Chebyshev's inequality.

Solution

Part (a):

It is reasonable to assume that the distribution is approximately normal. The required condition is that there are at least 10 successes and 10 failures in the sample. In this case there are 44 defective lightbulbs and 356 non-defective lightbulbs, thus both exceed the minimum of 10 required.

Part (b):

Note that $\hat{p}_X = \frac{44}{400} = 0.11$. So the standard error of $\hat{p}_X$ is $\sqrt{\frac{\hat{p}_X(1-\hat{p}_X)}{n}} = \sqrt{\frac{(0.11)(0.89)}{400}} = 0.0156$.

Part (c):

Since $\hat{p}_X = 0.11$, $0.11 - 0.10 = 0.01$, so that $\hat{p}_X$ is $\frac{0.01}{0.0156} = 0.64$ standard error away from 0.10.

Part (d):

(i) First compute $\hat{p}_Y = \frac{104}{400} = 0.26$. So $\hat{D} = \frac{0.11 + 0.26}{2} = 0.185$.

(ii) The standard error of $\hat{p}_X = 0.0156$ is obtained from part (b). The standard error of $\hat{p}_Y$ is $\sqrt{\frac{\hat{p}_Y(1-\hat{p}_Y)}{n}} = \sqrt{\frac{(0.26)(0.74)}{400}} = 0.0219$. So the standard error of $\hat{D}$ is $s_{\hat{D}} = \sqrt{\frac{1}{4}\left(0.0156^2 + 0.0219^2\right)} = 0.0134$.

Part (e)

$W = \frac{0.185 - 0.10}{0.0134} = 6.34$.

Question 6 (continued)

Part (f)

Suppose the true mean D is 0.10. Then the observed value of $\hat{D} = 0.185$ is 6.34 standard errors from the mean D. Using Chebyshev's inequality, the probability of observing a value of $\hat{D}$ within 6.34 standard errors of the mean of 0.10 is at least $1 - \frac{1}{6.34^2} = 0.975$. So the probability of observing a value as far from 0.10 as the one observed, or farther, is at most 0.025 if the true mean really is 0.10. Therefore, the p-value for this test is at most 0.025, which is less than 0.05, so the null hypothesis can be rejected. There is sufficient statistical evidence at the 0.05 level to conclude that the average proportion for all products that are defective is greater than 0.10.

Scoring

This question is scored in three sections. Section 1 consists of parts (a), (b) and (c), section 2 consists of part (d), and section 3 consists of parts (e) and (f). Each section is scored as essentially correct (E), partially correct (P), or incorrect (I).

Section 1 is scored as follows:

Essentially correct (E) if the response includes the following four components:

1. In part (a), states that it is reasonable to assume the condition is met *AND* provides appropriate justification by comparing the number of defectives and non-defectives to a reasonable number.
2. In part (b), calculates $\hat{p}_X$ correctly, either separately or in the process of showing the computation for its standard error.
3. In part (b), gives the correct formula for the standard error of $\hat{p}_X$.
4. In part (c), states the correct number of standard errors $\hat{p}_X$ is from 0.10.

Partially correct (P) if the response includes only two or three of the four components.

Incorrect (I) if the response includes at most one of the four components.

Notes

- In component 1, it is acceptable to check the sample size condition using $400 \times 0.1 = 40$ instead of the observed value of 44, because the sampling distribution refers to all possible samples.
- In component 4, transcription errors should not penalize a response if there is no ambiguity in how the error occurred. For instance, $\frac{0.11 - 0.10}{0.0156} = \frac{0.1}{0.0156} = 6.41$ is an acceptable transcription error.

Question 6 (continued)

Section 2 is scored as follows:

Essentially correct (E) if the response includes the following four components in part (d):

1. Correctly calculates $\hat{p}_Y$ either separately or in the process of showing the computation of $\hat{D}$.
2. Correctly calculates $\hat{D}$.
3. Gives the correct formula for the standard error of an average of two independent random variables.
4. Correctly computes the standard error of $\hat{D}$ *OR* if an incorrect but reasonable formula is given for the standard error, plugs the correct values into that formula. For instance, an incorrect but reasonable formula might use the standard errors rather than the squared standard errors of the estimated proportions.

Partially correct (P) if the response includes only two or three of the four components.

Incorrect if the response includes at most one of the four components.

Section 3 is scored as follows:

Essentially correct (E) if the response includes the following four components:

1. In part (e), correctly calculates W using the values from part (d).
2. In part (f), recognizes that Chebyshev's inequality should be used by substituting W for k.
3. In part (f), applies reasonable logic to make a conclusion based on using W and Chebyshev's inequality.
4. In part (f), makes a conclusion including linkage and context, consistent with the logic given in component 3.

Partially correct if the response includes only two or three of the four components.

Incorrect if the response includes at most one of the four components.

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2018 SCORING GUIDELINES

Question 6 (continued)

4 Complete Response

Three sections essentially correct

3 Substantial Response

Two sections essentially correct and one section partially correct

2 Developing Response

Two sections essentially correct and no sections partially correct

OR

One section essentially correct and one or two sections partially correct

OR

Three sections partially correct

1 Minimal Response

One section essentially correct

OR

No sections essentially correct and two sections partially correct

Scoring Worksheet

The following provides a scoring worksheet and conversion table used for calculating a composite score of the exam.

2018 AP Statistics Scoring Worksheet

Section I: Multiple Choice

_____	×	1.2500	=	_____
Number Correct (out of 40)				Weighted Section I Score (Do not round)

Section II: Free Response

Question 1	_____ (out of 4)	×	1.8750	=	_____ (Do not round)
Question 2	_____ (out of 4)	×	1.8750	=	_____ (Do not round)
Question 3	_____ (out of 4)	×	1.8750	=	_____ (Do not round)
Question 4	_____ (out of 4)	×	1.8750	=	_____ (Do not round)
Question 5	_____ (out of 4)	×	1.8750	=	_____ (Do not round)
Question 6	_____ (out of 4)	×	3.1250	=	_____ (Do not round)

Sum = _____
Weighted Section II Score (Do not round)

Composite Score

_____	+	_____	=	_____
Weighted Section I Score		Weighted Section II Score		Composite Score (Round to nearest whole number)

AP Score Conversion Chart
Statistics

Composite Score Range	AP Score
61-100	5
49-60	4
37-48	3
29-36	2
0-28	1

Question Descriptors and Performance Data

The following contains tables showing the content assessed,
the correct answer, and how AP students performed on each question.

2018 AP Statistics
Question Descriptors and Performance Data

Multiple-Choice Questions

Question	Topic	Key	% Correct
1	Exploring Data	D	35
2	Exploring Data	E	30
3	Exploring Data	D	70
4	Sampling and Experimentation	D	76
5	Probability and Simulation	E	8
6	Statistical Inference	B	60
7	Exploring Data	C	39
8	Statistical Inference	E	20
9	Probability and Simulation	C	28
10	Probability and Simulation	E	30
11	Exploring Data	C	85
12	Exploring Data	C	85
13	Exploring Data	C	80
14	Sampling and Experimentation	A	58
15	Exploring Data	D	55
16	Sampling and Experimentation	B	89
17	Statistical Inference	A	24
18	Exploring Data	B	51
19	Probability and Simulation	A	53
20	Statistical Inference	C	61
21	Probability and Simulation	E	51
22	Sampling and Experimentation	D	92
23	Statistical Inference	D	51
24	Exploring Data	A	39
25	Probability and Simulation	C	65
26	Statistical Inference	B	56
27	Probability and Simulation	A	40
28	Sampling and Experimentation	C	29
29	Statistical Inference	E	52
30	Probability and Simulation	D	36
31	Statistical Inference	A	75
32	Statistical Inference	E	23
33	Statistical Inference	E	38
34	Statistical Inference	D	58
35	Probability and Simulation	A	40
36	Statistical Inference	B	68
37	Probability and Simulation	B	31
38	Statistical Inference	B	38
39	Statistical Inference	B	48
40	Statistical Inference	B	26

AP Statistics

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