Multiple Choice.

1. A school guidance counselor examines the number of extracurricular activities that students do and their grade point average. The guidance counselor says, “The evidence indicates that the correlation between the number of extracurricular activities a student participates in and his or her grade point average is close to zero.” A correct interpretation of this statement would be that
   a. Active students tend to be students with poor grades, and vice versa
   b. Students with good grades tend to be students who are not involved in many extracurricular activities and vice versa.
   c. Students involved in many extracurricular activities are just as likely to get good grades as bad grades; the same is true for students involved in few extracurricular activities.
   d. **There is no linear relationship between number of activities and grade point average for students at this school**
   e. Involvement in many extracurricular activities and good grades go hand in hand.

2. The British government conducts regular surveys of household spending. The average weekly household spending (in pounds) on tobacco products and alcoholic beverages of 11 regions in Great Britain was recorded. A scatterplot of spending on alcohol versus spending on tobacco is shown below. Which of the following statements is true?

   a. The observation (4.5, 6.0) is an outlier
   b. There is clear evidence of a negative association between spending on alcohol and tobacco.
   c. The equation of the least-squares regression line for this plot would be approximately \( \hat{y} = 10 - 2x \).
   d. The correlation for these data is \( r = 0.99 \)
   e. **The observation in the lower right corner of the plot is influential for the least-squares line.**

3. The fraction of the variation in the values of \( y \) that is explained by the least-squares regression of \( y \) on \( x \) is
   a. The correlation
   b. The slope of the least-squares regression line
   c. **The square of the correlation coefficient**
   d. The intercept of the least-squares regression line
   e. The residual
4. An AP Statistics student designs an experiment to see whether today's high school students are becoming too calculator-dependent. She prepares two quizzes, both of which contain 40 questions that are best done using paper-and-pencil methods. A random sample of 30 students participates in the experiment. Each student takes both quizzes – one with a calculator and one without – in a random order. To analyze the data, the student constructs a scatterplot that displays the number of correct answers with and without a calculator for each of the 30 students. A least-squares regression yields the equation: \( \hat{\text{Calculator}} = -1.2 + 0.865(\text{Pencil}), r = 0.79 \). Which of the following statements is/are true?

i. If the student had used Calculator as the explanatory variable, the correlation would remain the same.
ii. If the student had used Calculator as the explanatory variable, the slope of the least-squares regression line would remain the same.
iii. The standard deviation of the number of correct answers on the paper-and-pencil quizzes was larger than the standard deviation on the calculator quizzes.

a. I only
b. II only
c. III only
d. I and III only
e. I, II, and III

Questions 5 & 6 refer to the following setting: Scientists examined the activity level of 7 fish at different temperatures. Fish activity was rated on a scale of 0 (no activity) to 100 (maximal activity). The temperature was measured in degrees Celsius. A computer regression printout and a residual plot are given below. Notice that the horizontal axis on the residual plot is labeled “Fitted Value.”

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>148.62</td>
<td>10.71</td>
<td>13.88</td>
<td>0.000</td>
</tr>
<tr>
<td>Temperature</td>
<td>-3.2167</td>
<td>0.4533</td>
<td>-7.10</td>
<td>0.001</td>
</tr>
<tr>
<td>S</td>
<td>4.78505</td>
<td>R-Sq = 91.0%</td>
<td>R-Sq (adj) = 89.2%</td>
<td></td>
</tr>
</tbody>
</table>

5. What was the activity level rating for the fish at a temperature of 20°C?
   a. 87
   b. 84
   c. 81
   d. 66
   e. 3

6. Which of the following gives a correct interpretation of \( s \) in this setting?
   a. For every 1°C increase in temperature, fish activity is predicted to increase by 4.785 units.
   b. The typical distance of the temperature readings from their mean is about 4.785°C.
   c. The typical distance of the activity level readings from the least-squares regression line is about 4.785 units.
   d. The typical distance of the activity level readings from their mean is about 4.785.
   e. At a temperature of 0°C, this model predicts an activity level of 4.785.
7. Which of the following statements is not true of the correlation $r$ between the lengths in inches and weights in pounds of a sample of brook trout?
   a. $r$ must take a value between -1 and 1
   b. $r$ is measured in inches
   c. If longer trout tend to also be heavier, then $r > 0$
   d. $r$ would not change if we measured the lengths in centimeters instead of inches
   e. $r$ would not change if we measured the weights in kilograms instead of pounds

8. When we standardize the values of a variable, the distribution of standardized values has mean 0 and standard deviation 1. Suppose we measure two variables $X$ and $Y$ on each of several subjects. We standardize both variables and then compute the least-squares regression line. Suppose the slope of the least-squares regression line is -0.44. We may conclude that
   a. The intercept will also be -0.44
   b. The intercept will be 1.0
   c. The correlation will be $(1/-0.44)$
   d. The correlation will be 1.0
   e. The correlation will also be -0.44

9. There is a linear relationship between the number of chirps made by the striped ground cricket and the air temperature. A least-squares fit of some data collected by a biologist gives the model $\hat{y} = 25.2 + 3.3x$, where $x$ is the number of chirps per minute and $y$ is the estimated temperature in degrees Fahrenheit. What is the predicted increase in temperature for an increase of 5 chirps per minute?
   a. 3.3°F
   b. 16.5°F
   c. 25.2°F
   d. 28.5°F
   e. 41.7°F

10. A data set included the number of people per television set and the number of people per physician for 40 countries. The scatterplot below shows the least-squares regression line. In Ethiopia, there are 503 people per TV and 36,660 people per doctor. What effect would removing this point have on the regression line?
   a. Slope would increase; y intercept would increase
   b. Slope would increase; y intercept would decrease
   c. Slope would decrease; y intercept would increase
   d. Slope would decrease; y intercept would decrease
   e. Slope and y intercept would stay the same
11. When we take a census, we attempt to collect data from
   a. A stratified random sample
   b. Every individual chosen in a simple random sample
   c. Every individual in the population
   d. A voluntary response sample
   e. A convenience sample

12. You want to take a simple random sample (SRS) of 50 of the 816 students who live in the dormitory on campus. You label the students 001 to 816 in alphabetical order. In the table of random digits, you read the entries

   95592  94007  69769  33547  92450  16632  81194  14873

   The first three students in your sample have labels
   a. 955, 929, 400
   b. 400, 769, 769
   c. 559, 294, 007
   d. 929, 400, 769
   e. 400, 769, 335

13. A study of treatments for angina (pain due to low blood supply to the heart) compared bypass surgery, angioplasty and use of drugs. The study looked at the medical records of thousands of angina patients whose doctors had chosen one of these treatments. It found that the average survival time of patients given drugs was the highest. What do you conclude?
   a. This study proves that drugs prolong life and should be the treatment of choice
   b. We can conclude that drugs prolong life because the study was a comparative experiment
   c. We can’t conclude that drugs prolong life because the patients were volunteers
   d. We can’t conclude that drugs prolong life because this was an observational study
   e. We can’t conclude that drugs prolong life because no placebo was used.

14. Tonya wanted to estimate the average amount of time that students at her school spend on Facebook each day. She gets an alphabetical roster of students in the school from the Registrar’s Office and numbers the students 1 to 1137. Then Tonya uses a random number generator to pick 30 distinct labels from 1 to 1137. She surveys those 30 students about their Facebook use. Tonya’s sample is a simple random sample because
   a. It was selected using a chance process
   b. It gave every individual the same chance to be selected
   c. It gave every possible sample of the same size an equal chance to be selected
   d. It doesn’t involve strata or clusters
   e. It is guaranteed to be representative of the population.

15. Consider an experiment to investigate the effectiveness of different insecticides in controlling pests and their impact on the productivity of tomato plants. What is the best reason for randomly assigning treatment levels (spraying or not spraying) to the experimental units (farms)?
   a. Random assignment allows researchers to generalize conclusions about the effectiveness of the insecticides to all farms
   b. Random assignment will tend to average out all other uncontrolled factors such as soil fertility so that they are not confounded with the treatment effects
   c. Random assignment eliminates the effects of other variables like soil fertility
   d. Random assignment eliminates chance variation in the responses
   e. Random assignment helps avoid bias due to the placebo effect.
16. The most important advantage of experiments over observational studies is that
   a. Experiments are usually easier to carry out
   b. **Experiments can give better evidence of causation**
   c. Confounding cannot happen in experiments
   d. An observational study cannot have a response variable
   e. Observational studies cannot use random samples

17. A TV station wishes to obtain information on the TV viewing habits in its market area. The market area contains one city of population 170,000, another city of 70,000 and four towns of about 5000 inhabitants each. The station suspects that the viewing habits may be different in larger and smaller cities and in the rural areas. Which of the following sampling designs would give the type of information that the station requires?
   a. A cluster sample using the cities and towns as clusters
   b. A convenience sample from the market area
   c. A simple random sample from the market area
   d. **A stratified sample from the cities and towns in the market area**
   e. An online poll that invites all people from the cities and towns in the market area to participate.

18. **Bias** in a sampling method is
   a. Any difference between the sample result and the truth about the population
   b. The difference between the sample result and the truth about the population due to using chance to select a sample
   c. Any difference between the sample result and the truth about the population due to practical difficulties such as contacting the subjects selected
   d. **Any difference between the sample result and the truth about the population that tends to occur in the same direction whenever you use this sampling method**
   e. Racism or sexism on the part of those who take the sample.

19. You wonder if TV ads are more effective when they are longer or repeated more often or both. So you design an experiment. You prepare 30-second and 60-second ads for a camera. Your subjects all watch the same TV program, but you assign them at random to four groups. One group sees the 30-second ad once during the program; another sees it three times; the third group sees the 60-second ad once; and the last group sees the 60-second ad three times. You ask all subjects how likely they are to buy the camera.
   a. This is a randomized block design, but not a matched pairs design
   b. This is a matched pairs design
   c. This is a completely randomized design with one explanatory variable (factor)
   d. **This is a completely randomized design with two explanatory variables (factors)**
   e. This is a completely randomized design with four explanatory variables (factors)

20. A researcher wishes to compare the effects of two fertilizers on the yield of soybeans. She has 20 plots of land available for the experiment, and she decides to use a matched pairs design with 10 pairs of plots. To carry out the random assignment for this design, the researcher should
   a. Use a table of random numbers to divide the 20 plots into 10 pairs and then, for each pair, flip a coin to assign the fertilizers to the 2 plots.
   b. **Subjectively divide the 20 plots into 10 pairs (making the plots within a pair as similar as possible) and then, for each pair, flip a coin to assign the fertilizer to the 2 plots.**
   c. Use a table of random numbers to divide the 20 plots into 10 pairs and then use a table of random numbers a second time to decide on the fertilizer to be applied to each member of the pair.
   d. Flip a coin to divide the 20 plots into 10 pairs and then, for each pair, use a table of random numbers to assign the fertilizers to the 2 plots.
   e. Use a table of random numbers to assign the two fertilizers to the 20 plots and then use the table of random number a second time to place the plots into 10 pairs.
21. You want to know the opinions of American high school teachers on the issue of establishing a national proficiency test as a prerequisite for graduation from high school. You obtain a list of all high school teachers belonging to the National Education Association (the country's largest teachers' union) and mail a survey to a random sample of 2500 teachers. In all, 1347 of the teachers return the survey. Of those who responded, 32% say that they favor some kind of national proficiency test. Which of the following statements is true?

a. Because random sampling is used, we can feel confident that the percent of all American high school teachers who would say they favor a national proficiency test is close to 32%

b. We cannot trust these results, because the survey was mailed. Only survey results from face-to-face interviews are considered valid.

c. Because over half of those who were mailed the survey actually responded, we can feel fairly confident that the actual percent of all American high school teachers who would say they favor a national proficiency test is close to 32%

d. The results of this survey may be affected by nonresponse bias

e. The results of this survey cannot be trusted due to voluntary response bias.

Free Response Section.

22. Sarah’s parents are concerned that she seems short for her age. Their doctor has the following record of Sarah’s height:

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>36</th>
<th>48</th>
<th>51</th>
<th>54</th>
<th>57</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>86</td>
<td>90</td>
<td>91</td>
<td>93</td>
<td>94</td>
<td>95</td>
</tr>
</tbody>
</table>

a. Make a scatterplot of these data.

b. Using your calculator, find the equation of the least-squares regression line of height on age.

\[ \text{height} = 71.95 + 0.3833(\text{age}) \]

c. Use your regression line to predict Sarah's height at age 40 years (480 months). Convert your prediction to inches (2.54 cm = 1 in)

\[ 71.95 + 0.3833(480) = 255.934 \]
\[ 255.934/2.54 = 100.761 \text{ inches} \]
\[ \text{(Approx 8’5”)} \]

d. The prediction is impossibly large. Explain why this happened.

EXTRAPOLATION!
23. Drilling down beneath a lake in Alaska yields chemical evidence of past changes in climate. Biological silicon, left by the skeletons of single-celled creatures called diatoms, is a measure of the abundance of life in the lake. A rather complex variable based on the ration of certain isotopes relative to ocean water gives an indirect measure of moisture, mostly from snow. As we drill down, we look further into the past. Here is the scatterplot of data from 2300 to 12,000 years ago:

![Scatterplot of data from 2300 to 12,000 years ago]

a. Identify the unusual point in the scatterplot. Explain what is unusual about this point.

See plot for point. It is unusual because it has a very high silicon value for its Isotope value.

b. If this point was removed, describe the effect on

i. The correlation – Correlation would become stronger (closer to -1) because it does not follow the overall pattern of the remaining points.

ii. The slope and y intercept of the least-squares line – The slope would decrease, and the y-intercept would increase, because the point is currently “pulling” the right side of the line up.

iii. The standard deviation of the residuals – The Standard deviation of the residuals would decrease because the point has such a large residual (therefore increasing the overall average distance from the line)

24. Long term records from the Serengeti National Park in Tanzania show interesting ecological relationships. When wildebeest are more abundant, they graze the grass more heavily, so there are fewer fires and more trees grow. Lions feed more successfully when there are more trees, so the lion population increases. Researchers collected data on one part of the cycle, wildebeest abundance (in thousands of animals) and the percent of the grass area burned in the same year. The results of a least-squares regression on the data are shown here.

![Graphs showing ecological relationships between wildebeest abundance and percent burned grass]

- The correlation between wildebeest abundance and percent burned grass is positive, indicating that as the number of wildebeest increases, more grass is burned.
- The slope of the regression line indicates the rate of change in percent burned grass per unit increase in wildebeest abundance, suggesting a strong relationship.
### Table: Regression Coefficients

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>92.29</td>
<td>10.06</td>
<td>9.17</td>
<td>0.000</td>
</tr>
<tr>
<td>Wildebeest (1000s)</td>
<td>-0.05762</td>
<td>0.01035</td>
<td>-5.56</td>
<td>0.000</td>
</tr>
<tr>
<td>S = 15.9880</td>
<td>R-Sq = 64.6%</td>
<td>R-Sq (adj) = 62.5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### a. Equation of the Least-Squares Regression Line

\[
\text{Percent of grass burned} = 92.29 - 0.05762(\text{wildebeest})
\]

### b. Slope Interpretation

For every increase of 1000 wildebeest, the predicted percent of grass burned decreases by about 0.058.

### c. Correlation

\[
r = \sqrt{0.646} = -0.804
\]

There is a strong, linear, negative association between the percent of grass burned and the number of wildebeest.

### d. Appropriate Model

Yes, it is appropriate because there is no pattern in the residual plot.

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### 25. Elephants and Beehives

Elephants sometimes damage trees in Africa. It turns out that elephants dislike bees. They recognize beehives in areas where they are common and avoid them. Can this be used to keep elephants away from trees? Will elephant damage be less in trees with hives? Will even empty hives keep elephants away? Researchers want to design an experiment to answer these questions using 72 acacia trees.

#### a. Identifying Units, Treatments, and Response Variable

- **Experimental Units:** Acacia trees
- **Treatments:** Active beehives, empty beehives or nothing in the tree
- **Response:** Damage to the trees caused by elephants

#### b. Randomized Design

Assign the trees numbers 01 – 72 and use a random number table to pick 24 different two digit numbers in this range. Those trees will get the active beehives. Continue to choose random digits until 24 more trees have been chosen. Those trees will get the empty beehives. The remaining trees will be left empty. Compare the damage caused by elephants to the three groups of trees.

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### 26. Public Opinion on Steroids

A New York Times article on public opinion about steroid use in baseball discussed the results of a sample survey. The survey found that 34% of adults think that at least half of Major League Baseball (MLB) players “use steroids to enhance their athletic performance.” Another 36% thought that about a quarter of MLB players use steroids; 8% had no opinion. Here is part of the Times's statement on “How the Poll was Conducted”:

The latest New York Times/CBS News Poll is based on telephone interviews conducted March 15 through March 18 with 1,067 adults throughout the United States ... The sample of telephone numbers called was randomly selected by a computer from a list of more than 42,000 active residential exchanges across the country, The exchanges were chosen to ensure that each region of the country was represented in proportion to its population. In each exchange, random digits were added to form a
complete telephone number, thus permitting access to listed and unlisted numbers. In each household, one adult was designated by a random procedure to be a respondent for the survey.

a. Explain why the sampling method used in this survey was NOT a simple random sample.

   Not all possible samples of size 1067 were possible. For example, using their method, they could not have had all respondents from the east coast.

b. Why was one adult chosen at random in each household to respond to the survey?

   If the household members who answer the phone have different opinions from those who don’t answer the phone, their opinions will be overrepresented.

c. Explain how undercoverage could lead to bias in this sample survey.

   If people without phones or with cell phones only have different opinions than the group of people with residential lines, these opinions will be underrepresented.

27. Many people start their day with a jolt of caffeine from coffee or a soft drink. Most experts agree that people who take in large amounts of caffeine each day may suffer from physical withdrawal symptoms if they stop ingesting their usual amounts of caffeine. Researchers recruited 11 volunteers who were caffeine dependent and who were willing to take part in a caffeine withdrawal experiment. The experiment was conducted on two 2-day periods that occurred one week apart. During one of the 2-day periods, each subject was given a capsule containing the amount of caffeine normally ingested by that subject in one day. During the other study period, the subjects were given placebos. The order in which each subject received the two types of capsules was randomized. The subjects’ diets were restricted during each of the study periods. At the end of each 2-day period, subjects were evaluated using a tapping task in which they were instructed to press a button 200 times as fast as they could.

a. How and why was blocking used in the design of this experiment?

   Each of the 11 individuals will be a block in this matched pairs design, with the order of treatments randomly assigned. This was to help account for the variability in tapping speed caused by the differences in subjects (regardless of caffeine).

b. Why did researchers randomize the order in which subjects received the two treatments?

   If all the subjects got caffeine the second time, the researchers wouldn’t know if the increase was due to the caffeine or due to practice with the task.

c. Could this experiment have been carried out in a double blind manner? Explain.

   Yes. Neither the subjects nor the people who came into contact with them during the experiment (including those recording the number of taps) need to know the order in which the caffeine or placebo was administered.