GROUND RULES:

- **Print** your full name clearly at the top of this page. Use the name that appears on university records.

- This is a closed-book and closed-notes exam. You can not use external notes of any kind.

- You may use a calculator. You may not use your phone as a calculator.

- This exam contains three parts:

    - Part 1. Multiple Choice. 22 questions, 2 points each (**44 points** total)
    - Part 2. Short Answer. 2 questions, 8 points each (**16 points** total)
    - Part 3. Extra Credit. 1 question (4 points total).

    This exam is worth **60 points** (but it is possible to get up to 64 points).

- Any discussion or inappropriate communication between you and another examinee, as well as the appearance of any unnecessary material, is not allowed. All violations will be reported to the Student Conduct and Academic Integrity Office immediately.

- You have **50 minutes** to complete this exam.

HONOR PLEDGE FOR THIS EXAM:

After you have finished the exam, please read the following statement and sign your name below it.

> *I promise that I did not discuss any aspect of this exam with anyone other than the instructor, that I neither gave nor received any unauthorized assistance on this exam, and that the work presented herein is entirely my own.*

PART 1: MULTIPLE CHOICE. Circle the best answer. Make sure your answer is clearly marked. Ambiguous responses will be marked wrong.

1. On March 2, 2023, AAA reports the average price of gasoline in Colorado was \$4.02 per gallon. On March 2, 2024, it was \$2.94 per gallon. Calculate the **percentage change** between these two time periods.

(a) 27% increase
(b) 27% decrease
(c) 108% increase
(d) 108% decrease

2. A researcher in the Department of Psychology wants to contact USC undergraduate students and ask them about their opinions on various psychosexual disorders. Before he does this, he must obtain approval from USC's Institutional Review Board (IRB). Why?

(a) Only the IRB can grant permission to release individual student's personal information and responses.
(b) He needs a valid procedure to determine if the results for USC students are statistically significant when compared to students at other universities.
(c) If he publishes the results through the peer-review process, the IRB needs to know why different groups of students have different opinions.
(d) He needs to ensure procedures for contacting students and interviewing them will not cause harm to the students.

3. In class, we talked about Dr. Joel Best's book *Damned Lies and Statistics*. What is this book about?

(a) How unethical researchers avoid legal liability when engaging in data fabrication or alteration.
(b) How the media presents statistics in a biased way to promote social issues.
(c) How politicians use statistics and data mining to target isolated voters.
(d) How general managers of sports teams are now using statistics to draft players and make in-game decisions.

4. A chemist has two methods of measuring the viscosity of a solution (units in mPa-s). She records five measurements for each method and calculates the average and the variance. Here are the results:

- Method 1: 6.0, 5.9, 5.9, 6.1, and 5.8 $\longrightarrow$ average = 5.94; variance = 0.013.

- Method 2: 5.7, 5.9, 6.0, 6.3, and 5.5 $\longrightarrow$ average = 5.88; variance = 0.092.

Which measurement method is more **reliable**?

(a) Method 1, because the average is larger
(b) Method 1, because the variance is smaller
(c) Method 2, because the average is smaller
(d) Method 2, because the variance is larger

5. The following graphical display shows the distribution of marital status for American women in 2017.
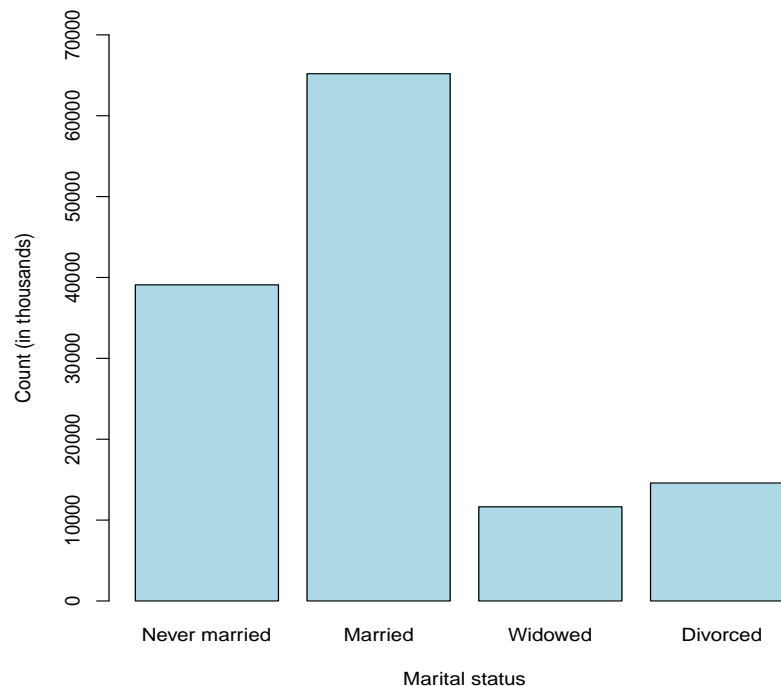
What type of graph is this?

(a) histogram
(b) line graph
(c) bar graph
(d) boxplot

6. When a quantitative variable can not be measured perfectly, we say there is measurement error. When a categorical variable has not been measured correctly, we say the measurement has been _____.

(a) blinded
(b) retracted
(c) misclassified
(d) randomized

7. When we did the FATHERLY FRIENDLY FARMS example in class, one student counted the number of F's to be 29, 29, and 29. The true number of F's is 48. This student's measurements suffered from

(a) bias only.
(b) random error only.
(c) bias and random error.

8. **Non-adherence** is a common problem in experiments involving human subjects, especially in clinical trials. What does non-adherence mean?

(a) Subjects may change their behavior during the experiment, so the experimental results may not match real life.
(b) Subjects do not follow the treatment regimen outlined by the investigators.
(c) Subjects may be under-represented on the basis of sex/gender, race/ethnicity, or some other factor.
(d) Confidential information on individual subjects cannot be revealed, so it is not possible to determine statistical significance.

9. My colleague in the College of Pharmacy wants to look at premature infants in a new study. She wants to determine if exposure to tetrahydrocannabinol (THC, the psychoactive constituent in marijuana) during pregnancy is a useful variable to help diagnose ADHD at age 4 years. Put another way, what does she want to know?

(a) If exposure to THC is an unbiased measurement.
(b) If exposure to THC has perfect reliability.
(c) If exposure to THC has predictive validity.
(d) If exposure to THC is a categorical variable.

10. A sample of 100 cars with Ford's EcoBoost engine was tested for highway driving. The miles per gallon (mpg) was measured for each car. Below is a stem plot of the observations. The stem is the tens and units digit (e.g., 33). The leaf is the tenths digit (e.g., 0.1).

```
> stem(mpg,scale=2)
   The decimal point is at the |

 30 | 0
 31 | 8
 32 | 5799
 33 | 126899
 34 | 024588
 35 | 01235667899
 36 | 01233445566777888999
 37 | 000011122334456677899
 38 | 0122345678
 39 | 00345789
 40 | 0123557
 41 | 002
 42 | 1
 43 |
 44 | 9
```

Which term best describes the **overall shape** of this distribution?

(a) skewed to the left
(b) bimodal
(c) symmetric
(d) skewed to the right

11. On June 4, 2021, the U.S. Food and Drug Administration approved semaglutide injection for chronic weight management in severely obese adults. A researcher at University of South Carolina wants to perform a clinical trial to determine if this same injection will prevent healthy pre-diabetic patients from becoming diabetic. For this experiment to be meet the required ethical standards for clinical trials, what must be true?

(a) An equal number of males and females must be included in the trial.
(b) There must be genuine uncertainty about whether the injection would be useful for healthy pre-diabetic patients.
(c) A sufficient number of patients must be enrolled so we can determine if the injection is statistically significant.
(d) All individual patient data should be released so medical researchers can verify the results.

12. What sentence best describes the difference between a completely randomized design (CRD) and a randomized complete block design (RCBD)?

(a) In a CRD, the effect of a lurking variable is balanced out among the treatment groups. In a RCBD, the effect of a lurking variable is removed.
(b) In a CRD, comparative design allows us to make statements about statistical significance for the treatments. In a RCBD, this can only be done for the blocks.
(c) In a CRD, randomization allows us to determine if a placebo effect is present. In a RCBD, blocking allows us to determine if a placebo effect is present.
(d) In a CRD, replication is used to reduce variation among the treatment groups. In a RCBD, replication is not needed because the blocks act as replicates.

13. A histogram of 500 observations is below:
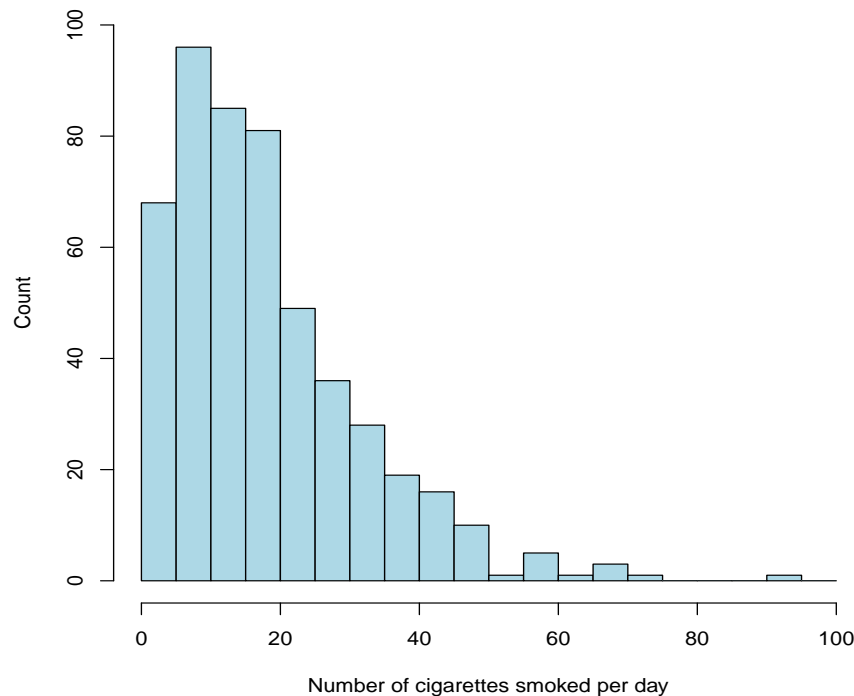
When I made this histogram, I used R's default selection for the intervals and their width. What interval width did R use?

(a) 2.5
(b) 5
(c) 20
(d) 100

14. In class, we introduced the term **innumeracy** when talking about statistics and the media. What does this term mean?

(a) A lack of understanding of basic mathematical ideas and numbers
(b) Not knowing how to tell the difference between statistical significance and practical significance
(c) People generally getting their information from media outlets with whom they agree
(d) Reporting observational study findings without discussing follow-up studies that contradict the findings

15. In the language of randomized comparative experiments, what is a **lurking variable**?

(a) It is a variable that is difficult to measure because of the Hawthorne effect.
(b) It is a variable that can be measured without bias and random error.
(c) It is a variable that prevents us from making a causal link between treatment and the response variable.
(d) It is a variable whose reliability is greater than its average value.

16. In class, we talked about a 1994 PhD dissertation whose author claimed,

> *"Every year since 1950, the number of American children gunned down has doubled."*

What was the **main point** of our discussion on this?

(a) We could validate this claim if we used an experiment to control for the effects of lurking variables (e.g., predisposition to mental illness, etc.).
(b) Statistics show gun violence is steadily getting worse in the United States.
(c) Some researchers make claims that are just nonsense.
(d) Using graphs for quantitative variables can be misleading when you are measuring a categorical variable.

17. I saw this graph online in an article written during the pandemic. The graph shows the biggest covid-19 worries among residents in two counties in Massachusetts.

What is the problem with this graph?

(a) The covid-19 data shown in the graph are quantitative.
(b) Two pie charts should be used because there are two counties represented.
(c) The percentages in the pie chart add up to 178%.
(d) Percentages are not valid measurements; percentage changes among the groups are better.

18. In class, we talked about the value of using identical twins in **matched pairs experiments**. What was the main point of this discussion?

(a) Identical twins serve as a natural form of replication.
(b) One twin has the authority to give informed consent for both individuals.
(c) Identical twins, as opposed to fraternal twins (those from different eggs), will produce measurements which are perfectly reliable.
(d) Because identical twins are almost perfectly genetically identical, the variation that exists between them is negligible. This allows us to remove the effects of lurking variables which are biological or genetical in nature.

19. Here is the distribution of the country of origin for international students studying in the United States in 2018:

Category	China	India	South Korea	Canada	Mexico	Other
Percentage	33.2%	17.9%	4.1%	2.4%	1.4%	??

For this to be a valid distribution, what percentage of international students must be in the "Other" category?

(a) 59.0%
(b) 41.0%
(c) 11.5%
(d) 1.2%

20. During the 2016 Republican primary, Donald Trump claimed he received more votes than any other candidate in previous Republican primary contests. This claim is **true**. However, I was critical of his intended meaning in class. Why?

(a) Substantial population growth over the years makes the number of votes an invalid measure when comparing himself to previous candidates.
(b) He should have cited the margin of error in the number of votes he received.
(c) The statement had no predictive validity at the time; he could not have possibly known he would win the general election.
(d) His statement dealt with only one quantitative variable and elections are observational in nature.

21. Any experiment or observational study that uses human subjects requires **informed consent**. What does this mean?

(a) The authors of the study must agree to inform the public of the study results.
(b) The nature of the study must be explained in advance to the subjects who then must voluntarily agree to take part.
(c) The institutional review board must agree the study will benefit science and it will not harm the subjects.
(d) The authors of the study must inform the institutional review board about the study and obtain the board's permission to go ahead.

22. Here are the winning times (in minutes) for women runners in the Boston Marathon each year between 1972 and 2018. All winning times have been rounded to the nearest minute.

Year	Time	Year	Time	Year	Time	Year	Time
1972	190	1985	154	1998	143	2011	143
1973	186	1986	145	1999	143	2012	152
1974	167	1987	146	2000	146	2013	146
1975	162	1988	145	2001	144	2014	139
1976	167	1989	144	2002	141	2015	145
1977	168	1990	145	2003	145	2016	149
1978	165	1991	144	2004	144	2017	142
1979	155	1992	144	2005	145	2018	160
1980	154	1993	145	2006	144		
1981	147	1994	142	2007	149		
1982	150	1995	145	2008	145		
1983	143	1996	147	2009	152		
1984	149	1997	146	2010	146		

If we wanted to see how the winning times change over time, which graphical display should we use?

(a) histogram
(b) bar graph
(c) line graph
(d) stem plot

PART 2: SHORT ANSWER. Give detailed responses. Please write clearly.

1. Three hundred (300) children will participate in a randomized comparative experiment with three painkillers:

- **Treatment group 1:** Ibuprofin

- **Treatment group 2:** Acetaminophen

- **Treatment group 3:** Codeine.

Before the experiment, each child's pain level is recorded on a 0-10 scale (0 = no pain, 10 = extreme pain). A standard dose of each drug will be administered. After a two-month period, each child's pain level will be recorded again.

(a) Researchers did not use a placebo drug (control) group. Describe what effect this may have on the final results. Be specific.

Answer: If there is a placebo effect (e.g., the children respond positively to taking anything), then the pain reductions seen in the experiment will be inflated. By not including a control group, the placebo effect will emerge as a lurking variable. This will impede our ability to say whether there is a causal link between treatment (drug) and the response variable (reduction in pain level).

(b) Researchers believe the three painkillers will produce different levels of pain reduction depending on whether a child is male or female. Design an experiment that acknowledges this. Describe how drugs will be assigned to the children (draw a figure if that helps).

Answer: We should use a RCBD where we block on biological sex (M/F).

1. Separate the 300 children by sex. Males in Block 1. Females in Block 2.

2. Within the male block, randomize the three drugs to the children. This could be done by using the Table of Random Digits or by using R.

3. Repeat for the female block.

(c) When comparing the levels of pain reduction for the three painkillers, the differences were statistically significant. Explain what "statistically significant" means.

Answer: The differences in pain reduction among the three drug groups were so large that they are probably not due to random chance (i.e., natural sampling variability).

2. A researcher selects a sample of 200 South Carolina adults (aged 18 and older) who have not received dental care in the past 10 years. Each adult in the sample is given a dental examination, and the researcher records the <u>number of dental caries</u> for each adult. "Dental caries" include teeth with cavities, decayed teeth, and teeth which are missing due to cavities. A histogram of the 200 observations is shown below:
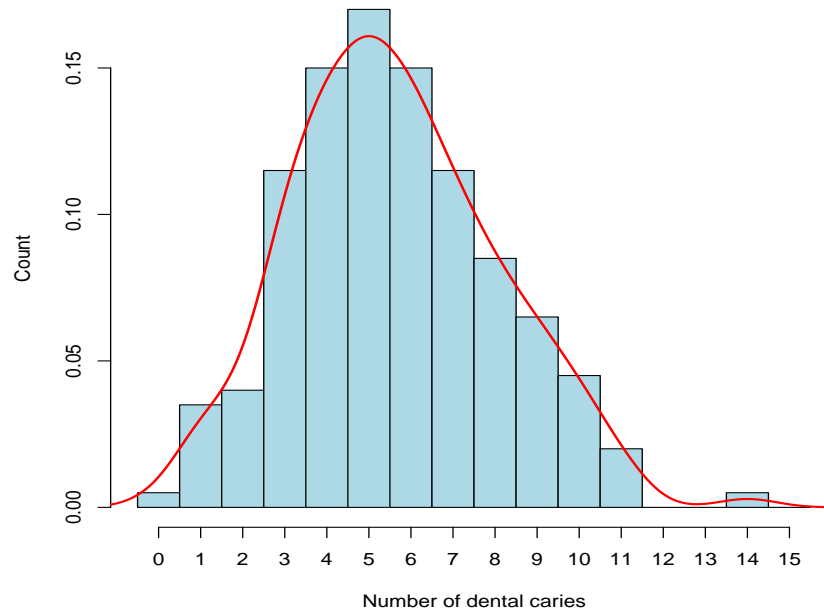
(a) Describe the physical characteristics you see in this histogram. I would like you to describe **four** characteristics.

- Center: The center of the dental caries distribution is around 6 caries.

- Variability: Almost all of the dental caries counts are between 0 and 11.

- Shape: This distribution has a single peak (at 5 caries) and is **approximately symmetric**. There may be a slight amount of skewness to the high (right) side.

- Deviations: There is an outlier at 14 caries. This observation does not follow the general pattern.

(b) Does it make sense to think about a population density curve in this example?

- If yes, then sketch a graph of the curve above and describe in words what this curve represents.

- If no, then explain why a population density curve would have no meaning or context in this example.

Answer: It does make sense because it makes sense to think of the 200 SC adults as a sample from a larger population. The population density curve is shown above. This curve describes the distribution of the number of dental caries <u>for all</u> SC adults who have not received dental care in the past 10 years.

PART 3: EXTRA CREDIT. Give a detailed response. Please write clearly.

In class, we talked about three examples of unethical behavior with data:

- the Duke-Potti cancer research scandal

- the LaCour-gay marriage debacle

- the Stewart retractions.

Select one of these examples and give a description of what it was about. What behavior occurred that was unethical?

Answer: These examples were discussed in Section 7.2 of the course notes.