1. (12 pts) A chimpanzee named Sarah, who had been raised in captivity since age one, was the subject in a study of whether chimpanzees can solve problems. Sarah was shown 30-second videotapes of a human actor struggling with one of several problems (for example, not able to reach bananas hanging from the ceiling, a record player not playing). Then Sarah was shown two photographs, one that depicted a solution to the problem (like stepping onto a box, plugging in the record player) and one that did not match that scenario. Researchers watched as Sarah selected one of the photos, and they kept track of whether Sarah chose the correct photo depicting a solution to the problem. They found that Sarah chose the correct photo in 7 of 8 scenarios that she was presented.

   a) (4 pts) Describe how you could use a coin to conduct a simulation analysis for testing whether Sarah genuinely does tend to choose the correct photo more than would be expected by random chance. Be sure to indicate how many times you would toss the coin and what variable you would keep track of.

   Toss the coin 8 times, once for each scenario that Sarah was presented. Let heads represent her choosing the correct photo, tails the incorrect photo. Count how many heads are obtained in the 8 tosses. Then repeat this set of 8 tosses a large number of times (say, 1000). Each time count how many of the 8 tosses result in heads.

   The graph below depicts the results of using the Coin Tossing applet to simulate Sarah’s choices 1000 times:

   ![Graph](image)

   (Notice that the numbers at the top of the graphs give counts of dots at each number. The number above 0 is hard to read: 4 dots are at the value 0.)

   b) (2 pts) Use this graph to determine the approximate p-value.

   The approximate p-value is 39/1000 = .039, because Sarah got 7 correct and 35 + 4 = 39 of the 1000 repetitions resulted in 7 or more successes.

   c) (3 pts) Describe what this p-value means. [Hint: The p-value is the probability of what, assuming what?]

   This p-value is the probability that Sarah would get 7 or more correct in 8 scenarios by chance alone, assuming that she was just guessing between the two photos on each scenario.
d) (3 pts) What would you conclude from this simulation analysis about whether Sarah is able to do better than guessing? Explain the reasoning process behind your conclusion.

This p-value is small enough to indicate that Sarah would be quite unlikely to get 7 or more correct in 8 attempts if she were just guessing. So, we have fairly strong evidence that Sarah was doing better than guessing and so really showed some ability to identify the problem-solving photo.

2. (15 pts) A statistics student wanted to investigate whether her dog Muffin was more likely to chase one ball or the other when a blue ball and a red ball were thrown at the same time. In 96 throws, Muffin chased the blue ball 52 times and the red ball 44 times.

a) (2 pts) For what proportion of throws did Muffin chase the blue ball? Also indicate the appropriate symbol for denoting this proportion.

The sample proportion of throws for which Muffin chased the blue ball is: \( \hat{p} = \frac{52}{96} \approx 0.542 \).

b) (2 pts) State (in symbols) the appropriate null and alternative hypotheses for testing the student’s question.

\( H_0: \pi = 0.5 \quad H_a: \pi \neq 0.5 \)

c) (2 pts) Describe (in words) the parameter of interest in this study.

The parameter \( \pi \) represents the actual probability (or long-run proportion of times) that Muffin would chase the blue ball.

d) (2 pts) Check whether the technical conditions for applying a one-proportion \( z \)-test are satisfied.

The conditions are: \( n \pi_0 \geq 10 \) and \( n(1- \pi_0) \geq 10 \). In this case \( n \pi_0 = 96(0.5) = 48 \) is larger than 10, and so is \( n(1- \pi_0) = 96(1-0.5) = 48 \).

e) (4 pts) Calculate the test statistic and p-value.

The test statistic is: \( z = \frac{0.542 - 0.5}{\sqrt{\frac{0.5 \times 0.5}{96}}} \approx 0.82 \). The two-sided p-value is \( 2(0.2061) = 0.4122 \).

f) (1 pt) What test decision would you make at the \( \alpha = 0.05 \) significance level?

Because the p-value is larger than 0.05, we fail to reject the null hypothesis.

g) (2 pts) Summarize your conclusion.
The observed sample data provide no reason to believe that Muffin has a preference for either color.

3. (8 pts) Suppose that the duration of human pregnancies (from conception to birth) follows a normal distribution with mean $\mu = 266$ days and standard deviation $\sigma = 16$ days.

a) (2 pts) Between what two values do about 95% of human pregnancy durations fall?

According to the empirical rule, 95% fall within 2 standard deviations of the mean, which is $266 \pm 2(16)$, which is $266 \pm 32$, which is between 234 and 298 days.

b) (3 pts) What proportion of human pregnancies last for more than 300 days (about ten months)?

The $z$-score for 300 days is: $z = (300 - 266) / 16 \approx 2.13$. The normal probability table reports the area .9834 for this $z$-score, so the proportion of pregnancies that last for longer than 300 days is $1 - .9834 = .0166$.

c) (3 pts) Only 8% of human pregnancies last for fewer than how many days?

Reading the normal probability table in reverse for an area of .0800 reveals the $z$-score to be between -1.40 and -1.41. If we let $k$ represent the duration we’re looking for, we want to solve $(k - 266) / 16 = -1.40$, which gives $k = 266 -1.40(16) \approx 243.6$ days.

4. (9 pts) In the mid-1980s, sociologist Shere Hite undertook a study of American women’s attitudes toward relationships, love, and sex by distributing 100,000 questionnaires in women’s groups. One of the questions was: Do you give more emotional support to your husband or boyfriend than you receive from him? A total of 4500 women returned the questionnaire.

An ABC News/Washington Post poll conducted at about the same time surveyed a random sample of 767 women, asking them the same question about emotional support.

a) (2 pts) Which survey would you expect to obtain a more representative sample of the population? Explain briefly.

The ABC News/Washington Post poll used a random sample, so it is more likely to be representative. The Hite survey was distributed only through women’s groups, and it seems reasonable to think that women who felt strongly about this issue were more likely to respond, so Hite’s sampling method is likely to be biased and therefore not representative.

Of the 4500 women who returned the Hite questionnaire, 96% said that they gave more emotional support than they received from their husbands or boyfriends. Of the 767 women interviewed in the ABC News/Washington Post poll, 44% claimed to give more emotional support than they receive.
b) (3 pts) Using only the poll corresponding to your answer to b), determine a 99% confidence interval for the relevant population parameter.

Based on the ABC News/Washington Post poll, a 99% confidence interval is:

\[ .44 \pm 2.576 \sqrt{\frac{.44(1-.44)}{767}} \], which is \(.44 \pm .046\), which is the interval (.394, .486).

c) (2 pts) Write a sentence interpreting what your confidence interval reveals.

We can be 99% confident that between 39.4% and 48.6% of all American women feel that they give more emotional support to their husband or boyfriend than they receive in return.

d) (2 pts) If you were to calculate the margin-of-error for both surveys (do not bother to actually do this calculation), which survey would have the smaller margin-of-error? Explain briefly.

The margin-of-error would be smaller for the Hite survey, because of its larger sample size.

5. (6 pts) Suppose that you want to estimate the proportion of full-time Cal Poly students who have at least one class on Fridays this quarter to within ±.06 with 95% confidence.

a) (1 pt) Identify the observational units in this study.

The observational units are full-time Cal Poly students.

b) (1 pt) Identify the variable in this study. Is it categorical or quantitative?

The variable is whether or not the student has at least one class on Fridays this quarter. This is a categorical (and binary) variable.

c) (1 pt) Identify the population in this study.

The population is all full-time Cal Poly students.

d) (3 pts) Determine the sample size needed to achieve your goal. [Hints: Re-read the first sentence of this question to remember what the goal is. Plug in any reasonable guess/estimate for what the proportion will turn out to be, and clearly state what your guess/estimate is.]

We need to solve \(1.96 \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} = .06\) for \(n\). Let’s guess that the sample proportion have at least one class on Fridays will turn out to be around \(\hat{p} = .5\). Then we need to solve \(1.96 \sqrt{\frac{.5(1-.5)}{n}} = .06\), which gives \(n = (1.96)^2(.5)(1-.5) / (.06)^2 \approx 266.8\). so 267 students would need to be sampled.