Experimental Design Project: Paper Helicopters

<u>Summary of the inference procedures</u>

"Statistical inference" refers to drawing conclusions about a population based upon data from a sample. The two types of inference we have studied are *significance tests* and *confidence intervals*. These are the contexts for which we have learned appropriate inferential procedures:

- 1-sample z. Inference about a population mean μ when the population standard deviation σ is known. This is rarely used in practice, since it is so seldom that σ is known when μ is not.
- 2-sample z. Comparing two population means μ_1 and μ_2 when both of their standard deviations σ_1 and σ_2 are known. This, like the 1-sample z, is rarely used.
- 1-sample t. Inference about a population mean μ when the population standard deviation σ is *not* known and must be estimated by the sample standard deviation s.
- Paired differences t. Inference about the mean μ of $X_1 - X_2$, when X_1 and X_2 are paired by experimental design.
- 2-sample t. Comparing two population means μ_1 and μ_2 when neither of their standard deviations σ_1 and σ_2 is known, and they must be estimated by sample standard deviations s_1 and s_2. (Note: If one assumes that the standard deviations are equal, then one may "pool" the data to estimate a single s. This is seldom done in practice, since there is seldom any reason to believe that $\sigma_1 = \sigma_2$, even if we hypothesize that $\mu_1 = \mu_2$.)
- 1-sample proportion. Inference about a population proportion p based on a sample proportion $\hat{p}$.
- 2-sample proportion. Comparing two population proportions p_1 and p_2 based on sample proportions $\hat{p}_1$ and $\hat{p}_2$. (In the case of testing the hypothesis $p_1 = p_2$, it *is* appropriate to estimate a single standard deviation for both $\hat{p}_1$ and $\hat{p}_2$ by pooling the data, since hypothesizing that $p_1 = p_2$ implies necessarily that the standard deviations of $\hat{p}_1$ and $\hat{p}_2$ are equal as well.)
- Chi-square test of goodness-of-fit. (Hypothesis test only.) Testing whether there is significant evidence against a claimed distribution of a categorical variable.
- Chi-square test of independence. (Hypothesis test only.) Testing whether there is significant evidence against the claimed independence of rows and columns in a two-factor table.
- Slope of a least-squares line. Inference about the slope β of a linear model $\mu_Y = \alpha + \beta x$ based on the least-squares regression line's slope b.

Designing experiments with helicopters

The paper helicopters you will be using this week are extremely versatile when it comes to experimental design. You can vary the height from which they are dropped, the length of the rotors, the weight you put on the bottom of them, and possibly many other things as well that you may think of.

In your group, design an experiment for six of the eight procedures described above, excluding the first two. You should briefly, but completely, describe the experiment; state what will be tested (for significance tests) or what will be estimated (for confidence intervals); and state what inference procedure is appropriate for the analysis. An example is given below.

> **Paired differences t.** This experiment will see whether there is any difference in the average ability of two students Zack and Xena to hit a target on the ground with their helicopters dropped from the third floor of Watts.
>
> Each student will make a helicopter, and a binder clip will be put on each one for stability. An "X" directly below the drop point will be drawn on the street outside the north Watts stairs in chalk. Each student will get three practice drops before beginning the experiment.
>
> Then Zack and Xena will stand at the top of the stairs and flip a coin. Heads, Zack drops first; tails, Xena drops first. They each drop their helicopters, trying to hit the target. This is called a single trial. They record for each drop how far each helicopter lands from the target. Then 30 such trials are performed.
>
> Paired differences are calculated and one-sample *t* inference procedures may then be used (1) to test $H_0 : \mu_{Z-X} = 0$ *vs.* $H_A : \mu_{Z-X} \neq 0$ and (2) to estimate μ_{Z-X}. (Note: the inference can only be drawn about Zack with his helicopter and Xena with hers. This experiment does not determine whether any difference is due to the person or the helicopter, since these are confounded.)

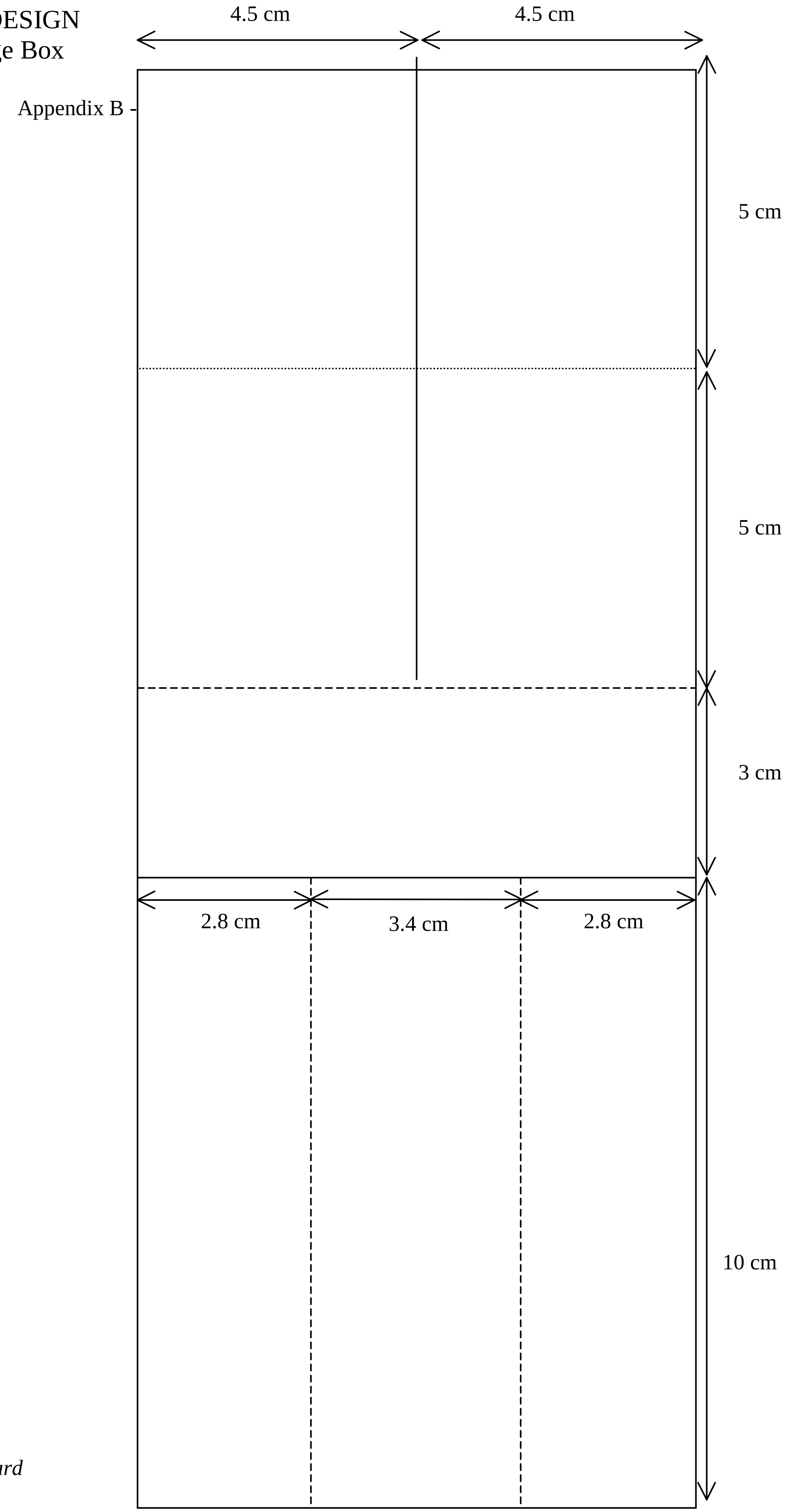
Write up each of your group's six experiments neatly on the blank paper provided; this is to be handed in. Be prepared to present any of them to the class and answer questions people may have about them.

Make a note of those that you would most like to perform. Each group will execute some, but not all, of their experiments.

Grading

This project, from the experimental design through the execution of the experiments to the statistical inference, will be graded out of 120 points. (Since I will be observing much of your work, it is possible for students in a single group not to receive the same grade if they do not contribute equally to the project.)

PAPER HELICOTPER DESIGN
Original Design by George Box



Gloria Barrett and Floyd Bullard
NCSSM

The following instructions use the George Box helicopter template on the previous page

1. Cut out the rectangular shape of the helicopter on the solid lines.

2. Cut one-third of the way in from each side of the helicopter to the vertical dashed lines on the solid line.

3. Fold both sides toward the center creating the base. The base can be stapled at the top and bottom. Try to be consistent about where the staples are placed. Use a paper clip to add some weight to the body

4. For long-rotor helicopters, cut down from the top along the solid center line to the horizontal dashed line.

5. For short-rotor helicopters, proceed as in step 4, but cut the rotors off along the horizontal line marked.

6. Fold the rotors in opposite directions.