With your partners, word process each of the following sections. Title each section in bold print.

**Put a project title and your names centered on the first page.**
Each team member must sign, indicating their approval of and effective contribution to the final product.

**Start each numbered section with a bold section heading.**

1. **Introduction**
Write a short introduction explaining the general question that you are answering with the project and how this is of interest to you, possibly including its relevance to engineering applications. Include the y variable you will be measuring, the 2 factors you will be investigating for effects on y, and the levels of those two factors. There should be at least six treatment combinations, at least a 3x2 factorial design.

2. **Anticipated Results including Background Knowledge/ Models**
Describe what you anticipate for results from your experiment including any background knowledge. For example you might anticipate that a 50% higher charge for a potato gun would increase distance by 10% or maybe increasing the charge by 5 ml will add 10 feet to distance.

What do you know from physics or engineering models for your experiment? For example, if you look at an introductory physics book under stopping distances, you will find that a simple model of stopping distances predicts that stopping distances are proportional to the squared velocity. If you were investigating cooling of cans of Coke, example 7 in chapter 1 of the differential equations text shows that for a simple model the temperature decays exponentially toward the ambient temperature. Knowledge from your physics, engineering, or math classes may be relevant. Or web searches can be useful. For some projects there will be no particular physical model that applies, but you will have experience or guesses about what you expect.

For example, suppose stopping distances of snowmobiles are proportional to speed$^2$.
For surface i and speed j stopping distances depend on a frictional, slipperiness factor for the i$^{th}$ surface, $c_i$, and speed, s.

\[ y_{ij} = c_i s_j^2 \]
You do not have to provide any such plots, just an explanation of what the model predicts. For this model if $s$ increases by 10%, then distance increases by 21%.

\[
\frac{\text{Dist at } 1.1 \times \text{speed}}{\text{Dist at speed}} = \frac{c_i \times (1.1 \times \text{speed})^2}{c_i \times (\text{speed})^2} = 1.21
\]

You may not have such an explicit mathematical model, but you may still be able to relate results to engineering experience or intuition. For example if we might expect the bounce height of balls to depend on surface type and ball pressure in a way that bouncing a ball of different type on wood results in a consistent percentage decrease in bounce height.

Suppose that the bounce height depends on a factor related to the ball, $b_i$, and surface $s_j$.

\[
y_{ij} \approx b_i s_j
\]
3. Data Collection Plan
The three basic strategies for reducing noise and effects of extraneous variables are blocking, controlling variables, and randomization.

Blocking can be a very useful experimental strategy. Very often blocking helps provide better insurance against bias and reduces noise in treatment comparisons. However, for simplicity in this project, do not plan to use blocks. Plan a completely randomized design. For most of your projects, the experiments are performed over a short time span with very uniform experimental units. In this case an unblocked, completely randomized design can work fine.

What variables will you be controlling in your experiment? There are usually multiple controlled variables. Consider investigating the effects of club composition and ball compression on golf driving distances. We could control club number (e.g. 7 iron, 2 wood etc.), club brand, club size, ball brand, the person driving the balls. By performing the drives in a short time period, we are effectively controlling temperature and wind speed, other potential extraneous variables that can obscure the treatment effects.

Randomization provides some insurance against biases resulting from other extraneous variables, either anticipate or unanticipated. We might want to run a blocked design, blocking consecutive drives/run order, to guard against biases introduced by fatigue along the way. However, for this project we would perform a completely randomized design. Explain exactly how many replicates you will have of each treatment combination. You should have at least 3 independent* replicates for each treatment combination. Do not have any repeated measurement of the same unit for different treatment combinations. For your randomizations state exactly how you performed the randomization. For randomization you might write numbers on slips of paper, use the book’s random number table, use JMP, use Excel or toss dice.

* In some case it can be beneficial to take multiple measurements once a given set of conditions has been set up. We might for example be cooling balls and measuring bounce height. With a particular paper airplane we might fly the plane 3 times to get a better measure of how far this plane flies. This is good idea, but these 3 measurements do not constitute independent replicates. You should average these 3 measures to give a single number for that replicate. Our sample size, n, is the number of independent planes we make, not the number of measured flights.

In some cases total randomization might be more hassle than it is potentially worth. If for example we are measuring heights that ball bounce on different surfaces, we might not want to be switching back and for between rooms with wood and cement floors throughout the experiment. Possibly doing all measurements on the cement floor and then switching to the wood floor may not present likely biases. However, if we change our measurement care as we grow tired of watching the balls, some bias could be introduced. If for practical reasons you did not randomize entirely, explain why you did not entirely randomize and why you feel this would not present problems in your experiment.

What measures are you taking to obtain precise and accurate measurements? Do you have a strategy to avoid poor runs at the beginning of the experiment? Exactly how will the measuring be done?

4. Data Collection Sheet
Develop randomized data collection sheets for all runs. Order the sheet in the order the runs will be performed. Include on the sheet the run number for each run. For a 2x3 factorial experiment with 3 replicates for each treatment combination, the runs would be numbered from 1 to 12. Include places on the sheet for notes for each run.
5. Task Assignment Plan
Describe how the tasks involved in the project will assigned to the team members. It is the obligation of all team members to assure that all members contribute effectively to the experiment, analysis, and write-up. I will be asking you along the way what your contributions were to the project. Who will fold the planes? Who will toss the planes? Who will measure the fight distances? Who will enter the data onto the collection sheet? Who will write each section? Who will proofread each section? Who will hand in the final product?