

The Gummy Bear Project

PROJECT WORKSHEET

Read this group worksheet and the grading rubric before starting your experiment!!!!

Note: Please delete any parts of this worksheet that are in color once you have completed the section.

Group Name: _____ Members: _____

The purpose of this experiment is to provide you the opportunity to practice the principles of experimental design and statistical inference. Project:

1. design a **well-controlled** experiment to test a factor that will affect how far gummy bears will "fly" from a catapult
2. carry out statistical inference procedures
3. prepare a typed statistical report of findings

- **Materials given:** tongue depressors, rubber band, pencil used as fulcrum, masking tape, a flat surface, gummy bears (25 for each treatment & 2 for trial runs), and tape measure.

**markers & pencils are provided by the group*

**No other materials may be used without prior approval by Ms. Groves*

• Plan for Your Launch Day

- **Submit completed worksheet for approval by Ms. Groves the class period prior to your launch date.**
- Once this worksheet is approved you can launch the following class.
- You must complete your to launch in 1 class period.
 - It will take you most of the period to do this correctly.
 - You must turn in your bears used in the experiment at the end of period.



Response variable (and explain how it will be measured) is **(fill in)** and units of measure will be **(fill in)**.

Define the factor and treatments. The following are Factors to consider for your experiment:

A common factor in the past has been angle of catapult; the treatments being the specific angle - 0, 30, 45, 60, or 75 degrees. Teams of 2 choose 2 angles and Teams of 3 choose 3 angles.

Other factors are:

- Position of catapult on the launch ramp
- Number of rubber band windings
- Position of gummy bear on the catapult
- Position of fulcrum in the catapult

Factor tested will be **(fill in)**.

Describe the **Treatments** (Teams of 2 need 2 treatments; and Teams of 3 need 3 treatments)

1)

Describe the **Experimental Units**.

- The experimental units are **(fill in)** and each treatment will have 30 experimental units.

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I. EXPERIMENTAL DESIGN

Describe your experimental design you will use? A well-designed experiment must incorporate 3 design components - Control, Replication, and Randomization.

Explain importance of each components and how you will incorporate them into this experiment:

1. Randomization:

- Explain in your words why randomization is important
- Explain how will you set up your random sample? Describe the process you will use to randomly assign your treatments.

2. Control:

- Explain in your words why control is important
- Refer to **Appendix 2 "Experimental Controls"** for a detailed list of controls for this experiment.

3. Replication:

- Explain in your words why replication is important and how it will be applied in this experiment

II. INFERENCE ANALYSIS (Preliminary Design)

To analyze the results of this experiment, we will conduct 2 inference analyses. We will calculate a confidence interval and perform a hypothesis test. To ensure that our analyses are statistically reliable, we have outlined them below and explained the necessary conditions needed to calculate the statistics.

A. Hypothesis Test

- Name the Hypothesis Test:
- Name the Statistical Test of Hypothesis:
- Define population parameters:
 $\mu_1 =$
 $\mu_2 =$
 $\mu_3 = \dots$ (if applicable, for teams of 3)
- Define hypothesis (null and alternative in both symbols and words):
(For teams of 3, define 3 TOH's - μ_1 vs. μ_2 , μ_1 vs. μ_3 , μ_2 vs. μ_3)
 H_0 :
 H_a :
- Define your significance level:

III. YOUR PREDICTIONS

What do you expect to happen?

- ...

What could possibly go wrong?

- 1) ...
- 2) ... etc

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IV. INFERENCE ANALYSIS (Statistical Analysis of Experiment)

A. Hypothesis Test (continued)

- Check Conditions: **Remember to check conditions for all treatment groups**
 - Random
 - Independent
 - Normal
- Test Statistics (Give the means compared, test statistic, p-value, and df)... **Bonus points for a clearly labeled normal graph**
- Interpret the test(s) in context:

B. Confidence Interval to Support your Hypothesis (For teams of 3, create CI's that match your TOH)

- Name the Confidence Interval:
- Name the Statistical Interval:
- Define the Confidence Level :
- Check Conditions (if applicable and/or state the condition was check in TOH):
 - Random
 - Independent
 - Normal
- Confidence Interval(s) Statistics: [Give the CI formula with numbers, df, and CI]... **Bonus points for a clearly labeled normal graph**
- Interpret Confidence Interval(s) in context:

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FORMAL WRITTEN REPORT

Introduction

Xxx

Summary of your Treatment Data

Xxx

Summary of Inference Procedures

Xxx

Reflections on Your Experiment

Xxx

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Important!!! Appendix 1:

What must be include in the Final Report (all parts must be typed)

See my website for samples

- I. Introduction - Write in "FORMAL WRITTEN REPORT" section above.
 - Written in paragraph form (**about 2 paragraphs**) -
 - explain the purpose of the experiment (and describe the experimental units, factors, treatments)
 - explain the 3 key components of a well-designed experiment (and how you implemented them in your design)
 - identify all inference procedures you did in your analysis (the details will be in the Inference Analysis Section)
- II. Raw data
 - The raw data is presented in a well-organized table including treatments, assigned random number for each experimental unit, response variable and note any outliers. **See Appendix 3.**
- III. Summary Statistics
 - The raw data is presented in a well-organized table including mean, standard deviation, n, 5-number summary, IQR, and note any outliers. **See Appendix 4.**
- IV. Graphs
 - Box plots comparing each treatment using the same scale; and histograms for each treatment are provided. **See Appendix 5.**
- V. Summary of your Treatment Data - Write in "FORMAL WRITTEN REPORT" section above.
 - Written in paragraph form clearly comparing your treatments (Remember CUSS and BS).
- VI. Summary of Inference Procedures - Write in "FORMAL WRITTEN REPORT" section above.
 - Written in paragraph form summarize the results of your experiment to someone without a statistical background (**about 3 paragraphs**). Include the following
 - Summarize your test of hypothesis and how it relates to your experiments results.
 - Summarize your confidence intervals and how they relate to your experiments results.
 - Clearly your hypothesis and whether the statistical analyses (Both TOH and CI) support it.
- VII. Reflections on Your Experiment - Write in "FORMAL WRITTEN REPORT" section above.
 - Written in paragraph form with a **minimum of 5 sentences**-
 - What went wrong? No experiment is perfect!
 - What you would do differently if you were to do this experiment again.

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Appendix 2: Experimental Controls

A well-designed experiment included a great deal of pre-planning. This is critical to control for all extraneous factors to ensure reliable results

TIP: Make sure to do enough test launches while you are designing your experiment to ensure you have a well-designed controlled experiment. [Modify these control suggestions for your experiment.](#)

A. Controls for the Catapult Design:

- ☐ Gummy Bear placement (location, bear horizontal or vertical)
- ☐ Catapult (tongue depressors) placement on the board
- ☐ Fulcrum(pencil) location
- ☐ Rubber bands (number and placement)
- ☐ Treatment controls to secure EACH angle of launch pad (*i.e., compass placement, what will you use to change the catapult for the angle, how will you switch when and how to change the angle elevation, etc*) will be:
 - Angle (fill in) will be set up...
 - Angle (fill in) will be set up...
- ☐ Other Design Controls

B. Controls for Consistent Launching and Assigning Treatments:

- ☐ How will you control that each launch is consistent?
 - Shooter
 - Measurer
 - Board placement and how you will secure it so it does not move
 - Other controls for consistent launching
- ☐ How will you control for consistent measurement of how far Gummy Bear goes?
 - Starting measurement location
 - Ending measurement location (i.e. initial landing position or final landing position)
 - How will you mark the starting and ending locations?
 - How will you set up your tape measure?
 - Units of measurement
 - Other controls for consistent measurements

C. Environment: How will you control your environment from extraneous factors (i.e. bears hitting walls, students walking on bears, etc.)?

- ☐ (fill in)...

D. Subjects: How will you control that your subjects (Gummy Bears) are safe and assigned to the correct treatment?

- ☐ (fill in)...

E. Other Controls

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Appendix 3a: The Launch and Collecting Data

- 1) Have your Raw Data Table ready to collect the data
- 2) Do a few test launches to check you have a well-controlled experimental design

3) Make sure Ms. Groves observes the first few trials of your launch (or you will have to relaunch)

Raw Data Table: In a well-organized table including treatments, assigned random number for each experimental unit, response variable and note any outliers. Use the template below. *Change everything in red.*

See sample: <http://www.brunswick.k12.me.us/pgroves/files/2013/05/Gummy-Bear-Sample-Raw-Data-Table.jpg>

Data Table for Gummy Bear Launching(UNITS)

	TREATMENT 1 (DESCRIBE)		TREATMENT 2 (DESCRIBE)	
TRIAL #	SUBJECT #	DISTANCE	SUBJECT #	DISTANCE
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

***Note any outliers:**

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Appendix 3b: The Launch and Collecting Data

Data Table for Gummy Bear Launching (UNITS)

TREATMENT 1: (fill in)

TREATMENT 2: (fill in)

TREATMENT 3: (fill in)

	TREATMENT 1		TREATMENT 2		TREATMENT 3	
TRIAL #	SUBJECT #	DISTANCE	SUBJECT #	DISTANCE	SUBJECT #	DISTANCE
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

*Note any outliers:

Appendix 4: Summary Statistics

Summary Statistics by Treatment (units)

	Treatment #1 (describe)	Treatment #2 (describe)	Treatment #3 (describe)
Sample size			
Mean			
Standard Deviation			
Minimum			
Q1			
Median			
Q3			
Maximum			
IQR			
Outliers (Bear #'s)			

Comments:

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Appendix 5: Graphs

Box plots comparing each treatment using the same scale; and histograms for each treatment are provided.

I. Box Plots by Treatment (**units**)

II. Histograms by Treatment (**units**)