**Windmill Lab: Investigating Variables and Power** Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Block\_\_

**Learning Goal:**

1. Students will conduct a controlled experiment to maximize the power output of a windmill.
2. Students will use the LHS Science Rubric to plan out and analyze an experimental design of their own making

**Pre-lab:**

As a lab group/ class, discuss the following:

1. List all variable(s):
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
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1. Choose one of the variables listed above as your independent variable. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Dependent Variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Variables you will keep constant in your experiment. These things will stay the same every single trial:
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
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* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
1. Is your independent variable qualitative or quantitative (Circle one)? Are the measurements you take on the dependent variable quantitative or qualitative (Circle one)?
2. Based on your answers to #5, what kind of graph would you make? … Bar Graph or Line graph with a trend line
3. Write a hypothesis for your experiment: (If..then..because..)

If we (***thing******changed***)

Then (***result***)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Because (***reason***) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. As a group, write a controlled, reproducible procedure ***on lined paper or typed***. Read the “Need to Know” section below before you start writing the procedures. Everyone in the group must have their own copy of the procedures and data table.

**“Need to Know” Equations:**

To calculate how much energy is required to lift the washers, you must first measure the mass of the washers in kilograms as well as how high your windmill lifts the washers in meters. If your windmill cannot lift the washers to the top, you must reduce the number of washers in the cup.

***Energy (Joules) = Mass (kg) X Acceleration of Gravity (9.8 m/s2) X Height (0.5 m)***

To measure power, you must measure how long it takes to lift the washers to the top in seconds.

***Power (Watts) = Energy (Joules)***

 ***Time (Seconds)***

**8. Procedure:** Step by Step, detailed instructions about how you will design your blades and how you will control each variable, how you will change your independent variable, and how you will collect data

***Blade Design*** *(explain how you decided on the shape/style of blades)*

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***Independent Variable*** *(explain how you will change your Independent Variable – on the windmill tower)* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Data*** *(explain how you will collect Data)* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Drawing of blades here:** (to scale if possible – use **Centimeters** as units)

1. **Gather data in the data table below. Complete your calculations in space provided.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trial: Describe IDV:****\_\_\_\_\_\_\_\_\_\_\_\_\_\_****\_\_\_\_\_\_\_\_\_\_\_\_\_\_** | **\*\*1\*\*****# of washers lifted** | **2****Mass of washers lifted****(grams)****(#1) x 14.5** | **3****Kg Mass of washers****lifted****(Grams/1000)****(#2) / 1000** |  **4****Mult. By****Accel of Gravity****(#3) x 9.8** | **5****Mult by Height****(#4) x 0.5** | **6****Energy****(J)****Same As****#5** | **\*\*7\*\*****Time to lift washers to top** | **8****Divide****Energy by Time****#6 / #7** | **9****Power****(W)****Same as****#8** |
| 1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Control Group | \_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_g | **\_\_\_\_\_\_\_\_\_\_\_\_kg** |   \_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_J | \_\_\_\_\_sec | \_\_\_\_\_\_W | \_\_\_\_\_\_\_W |
| 1.\_\_\_\_\_\_\_\_\_\_\_\_\_\_Control Group | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 1..\_\_\_\_\_\_\_\_\_\_\_\_\_\_Control Group | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 2.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 3.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 3.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 3.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 4.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 4.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 4.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 5.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 5.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 5.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 6.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 6.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |
| 6.\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_ |  |  |  |  |  |  |  |  |

Windmill Design Lab-Data Table *(if # of washers remains the same, columns #1-6 will be the same!)*

**Calculations: Show your work on the back of this paper.**

**Energy (J)** = Mass **(\_\_\_\_\_\_\_\_kg**) X Acceleration of Gravity (**9.8 m/s2**) X Height (**0.5m**) = \_\_\_\_\_\_\_\_\_ Joules

 \_\_\_\_\_\_\_ kg X 9.8 m/s2  X 0 .5 m = \_\_\_\_\_\_\_\_\_\_\_\_ J

**Power (W)** = Energy (Joules) **÷** Time (Seconds) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **Watts (W)**

**Graph**: Make sure to include your IV of the X axis, DV on the Y axis, labels and units, a “line of best fit”, and a key in necessary, Title. NEVER CONNECT POINT TO POINT



Y-Axis (Dependent Variable- depends upon what you changed)

POWER (watts)

 \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**X-Axis** = Independent Variable (variable you changed)

**Conclusion:**

1. Did the results of your experiment **support or refute** your hypothesis?
2. Which trial was the most effective at generating power (describe the independent variable)?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Describe any possible errors in your experiment (Please don’t include things like, “We might have measured incorrectly.”): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. How would you improve this experiment to avoid the errors listed in question 10? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Listen to other groups present their experiment and take notes on the most effective designs for other variables:

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Combining the information from your experiment as well as other groups’ experiments, **draw and label** the most powerful windmill you could make with the materials we have in class.