Lab1: How Big Is Big?

Group Number: _____ Section Number:_____

Name _____

Other team members _____

(Circle the name of the person who acted as leader)

SAFETY SECTION:

The experiments used in this lab are under development and caution should be used. One experiment uses weights, another uses water, another uses electricity. If water is spilled it must be cleaned up promptly. Please alert the instructor or TA if you have a safety incident. As always, long pants, closed toed shoes and safety glasses must be worn at all times.

Begin your lab by holding a team planning session (3 minutes):

1. Review the lab and read the safety section if you haven't already.
2. One person should serve as leader/coordinator. All team members should strive to take make the team function better through various roles: observer, recorder, devil's advocate, etc. Ask for each other's input and opinions, help each other, and try to come to consensus after an appropriate amount of brainstorming and analysis.
3. Make a plan for how you will complete the lab activities. Each person should fill out their own lab report as activities are completed. At the end of the hour, after cleaning up, get the TA to initial the end of your report.

Background: As a student engineer, you often solve homework problems and generate numbers with units attached. The goal of this lab is to help you gain some intuition on the size or amount of quantities that you may encounter. Another goal is to have you practice the skill of doing rapid estimations of quantities in your head. Do not worry about getting the "exact right" numerical answer in this lab. Feel free to use the internet (your phones) to look up information for most problems; however, in one instance we want you to test your intuition without using outside information.

Project: Go to the 3 stations set up on the tables, perform the indicated activities, and answer the questions in the spaces below. The stations and questions do not need to be done in any particular order.

1. **Power**: There is a hand crank that can be used to generate electrical power, which is dissipated across a resistive load (or could be used to instead charge your phone). How much power can someone generate with their hands?
    a. One multimeter measures electrical current (units amps or A), another measures electrical potential (units volts or V) across the load. What is the formula to generate Watts (power) from these two quantities?

    b. How many Watts of electricity can you consistently generate with your hands?

    c. A hair dryer requires about 1 kW of power. An automobile gasoline engine produces about 25 kW of power. How many human-powered hand cranks equals one hairdryer? one car engine?

    d. The human body puts out about 100 W of heat while sitting and 300 W while exercising vigorously. How many Watts of cooling must be used by BYU Physical Facilities to keep the temperature stable when the Marriott Center is full of people at a devotional or a basketball game in January? (Also, compare 100 W to the power output of a typical candle flame.)

    e. Electrical current can be compared to flow of water through a pipe, in which an electrical generator is like a pump or turbine. Explain what electrical current and potential each represent in the water-in-pipe analogy. Explain what units you would use in the analogy.

2. **Energy:**
    a. How much does the temperature of 1 mL of water increase when 1 calorie of heat is added?

b. How much does the temperature of 1 pint (16 oz) of water increase when 1 Btu of heat is added?

c. Draw three squares whose areas represent 1 calorie, 1 Joule, and 1 Btu; scale the sizes so the areas are in the correct relative proportions.

d. If you are made of water and generate 100 W of heat while sitting, then if you were insulated, how many ^{o}C and ^{o}F per hour of temperature increase would you have? First guess what you think it is, then calculate.

e. How long would it take a typical coal powerplant to boil the water in an Olympic size swimming pool? First guess what you think it is, then calculate.

3. **Pressure**: There are weights and a rod with a small cube on the bottom of the rod. Put weights on the rod and use the rod to generate a particular pressure on the square surface on the underside of the cube. There is also a spring-scale to measure weight.
    a. What is the formula for pressure in terms of force/weight and area?

    b. How much weight would you need to put on the rod in order to create "atmospheric pressure" on the underside of the square area? Explain your reasoning.

    c. How does "atmospheric pressure" feel when applied to the top of your hand with weights? In other words, put the right amount of weight on the rod, then balance the square on your hand.

    d. The tire on your car or bike is filled to the recommended pressure. How much weight can the tire hold up? Do a quick calculation to make a reasonable estimate.

4. **Volumes**: There are 3 different sized cubes representing different volumes.

    a. What are the different volumes represented?

    b. Without using any sources of information other than what is in your head, estimate how many gallons goes in a cubic foot:

c. Test your intuition by filling the cubic foot tank partially or fully. Revise your estimate from part b based on your observation. (carefully empty the tank when you are done)

d. How much does a gallon of water weigh in lbs-f? How heavy is a cubic foot of water?

Grading Rubric (to be completed by TAs)

	Points	Max
Completed Activities and write-up		6
Accurate calculations and reasonable estimates		3
Safety and cleanup: **TA initial:_____**		1
Total		10