Experiment 8

Measuring Pressure

Equipment List: Gallon Size Freezer Bag, Quart Size Freezer Bag, Stiff Cardboard\*, 40 Nickels, Cell Phone with Phyphox downloaded on it, ruler, masking tape.

(\*can be substituted with a thin hardback book)

Pressure is the measure of the amount of force applied over an area.

Where the force is measured in Newtons, the area in square meters, and the pressure in Pascals.

One Pascal is equal to one Newton/meter2.

On the application called Phyphox, you will use the function called “Pressure” located in the Raw Sensors list. The pressure is measured in hectoPascals. There are 100 Pascals to one hectoPascal.

So, a reading of 981.23 hPa is equal to 98,123 Pa.

You will use both a freezer bag and your cell phone to measure the increase in pressure inside of the freezer bag. By placing the cell phone inside of the freezer bag, and filling the bag mostly with air and sealing the bag, a change in pressure is measured as weights are added to the top of the bag.

Coins

Freezer Bag

Freezer Bag Seal

Cardboard

Cell Phone

Hard Surfaced Table

Part 1

Gallon Size Freezer Bag

1. Measure the approximate length and width of the area on top of the bag. As you can see from the illustration, when the freezer bag is partially inflated, only a portion of the top surface of the bag comes into contact with the cardboard. Partially fill the freezer bag with air and seal the bag (no cell phone, yet), flatten out the “top” of the bag with your hand and centimeter scale ruler and measure to your best ability the length and width of this “top” surface. Record the length and the width, in meters, into the Excel worksheet. Determine the approximate area to which the forces are applied.
2. Open the freezer bag. Open the application Phyphox and start the function “Pressure”. Place your cell phone into the freezer bag and mostly seal the bag, leaving enough of an opening to blow air into the bag. Partially fill the bag with air and seal the bag. Place the cardboard on top of the freezer bag. Wait to a count of 5. Place your first weight onto the cardboard. Wait again for a count of 5. Continue placing the weights onto the cardboard, waiting each time to a count of 5. Counting to 5 will allow enough data points to “measure” each of the pressures. When you are finished take all of the weights, and the cardboard off of the freezer bag. Open the freezer bag and stop the Pressure function.
3. To retrieve the data turn your phone sideways (makes it easier to see the graph) and tap anywhere on the graph. Below the graph you should see a “Pick Data”. Tap on the “Pick Data” and then tap on the graph where you wish to get a data point. Do this for each of the portions showing a constant pressure corresponding to each of the weights added (including the portion with only the cardboard). Record both the weights and the pressures into the Excel worksheet. Do not include the weight of the cardboard. This is considered your zero added mass point.
4. Plot the data points as a graph of Force (y-axis) versus Pressure (x-axis). Error bars are not necessary since they are very small compared to the data values. The slope of the line should be equal to the area to which the force is applied. Determine the uncertainty in the slope of the line.
5. Repeat 4 more times for a total of 5 data sets.
6. Calculate the average slope from all 5 graphs, including the total uncertainty. This represents the average area that the forces are being applied.

Part 2

Quart Size Freezer Bag

Repeat parts A through F using a quart size freezer bag.

Results

Compare the average value of the gallon size freezer bag area with the approximate area value from part 1 part A. Compare the average value of the quart size freezer bag with the approximate area value from part 2 part A.

Questions for Discussion

1. It is difficult to get a precise measurement of the length and width of the area of the freezer bag to which the forces are being applied. Determine a reasonable amount of uncertainty in measuring the length, and a reasonable amount of uncertainty in measuring the width, describing why you chose these amounts. Then, determine both the area and the uncertainty in the area. Show all work.
2. The U.S. Mint declares that the mass of a newly minted nickel is equal to a value of 5.000 grams. All of the digits in this number are significant. Using the information from the Uncertainty Analysis Instructions file, determine the total uncertainty in the weight (in Newtons) of 40 nickels. Is this uncertainty large enough to be used as an error bar for the graph? Looking at the scaling of the graph may be helpful in answering this question.
3. In this experiment the same weights are used to generate the pressures in both the gallon size freezer bag, and in the quart size freezer bag. Are there any differences between these two bags and the pressures generated? If so, why did this occur?
4. If you place the cell phone into the gallon size bag, and placed cardboard on top of the bag, then placed the quart size bag on top of the cardboard, with another cardboard on top of the quart size bag, would you get a different slope value for the gallon size bag when adding the same weights on top of this combination? If so, by how much would the slope change? If not, explain why not.