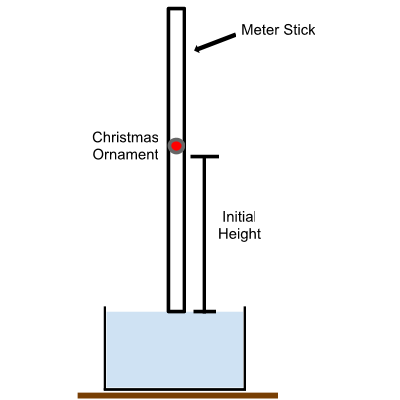
I wish to determine how the initial height of which a Christmas ornament (a spherically shaped ball) is dropped from affects the amount of time required for the ornament to be completely submerged in a container of water with the time required for the ball to completely resurface.

In this experiment I will drop a Christmas ornament from various heights into a container of water. After I have dropped the ball, I will measure the amount of time required for the ornament to be completely submerged in the container of water with the amount of time needed for the ornament to completely resurface. I will record the total time by using a video camera to film the submerging and resurfacing o the ornament. In this experiment, my independent variable is the initial height of which the ball is dropped from and my dependent variable is the time required for the ornament to resurface.

There are five variables that I see that can affect the results of this experiment. Therefore, I must control these variables to limit their influence on the data I intend to collect. To effectively control these variables, I must do the following:

* Christmas Ornament (Ball) Used
  + For each trial and iteration, I will drop the same ornament.
* Container Used to Hold Water
  + For each trial and iteration, I will use the same container to drop the ornament into.
* Volume of Water in Container
  + For each trial and iteration, I will drop the ornament into the container with the same amount of water inside. Between each trial, I will check the volume of the water and adjust it if needed to keep a constant volume.
* Environment
  + The environmental conditions will be maintained as constant as possible throughout the course of the experiment.
* Data Recording
  + I will be using the same video camera to record the resurfacing time. The camera will be placed in the same position for each trial and iteration.

The experiment will proceed as followed. I will drop an ornament (d=6cm) from 6 different heights. A meter stick will be aligned with the edge of the wall to ensure that the measurements of the initial height are indeed vertical. The bottom of the ornament will be aligned to the desired initial height. I will than drop the ornament into a container (3 L) with a total of 2 L of water in the container. I will than record the the ornament being completely submerged and its complete resurface (the ornament coming completely out of the water) with a video camera. Then I will use a video viewer software to review the footage and will record ((the time-stamp of the ornament resurfacing) - (the time-stamp of the beginning of the ornament's submersion)) to obtain the resurfacement time.

**

*\*Not drawn to scale\**

I will repeat this experiment for five iterations before beginning the next trial. The first trial’s initial height will be 20 cm. Each successive trial will increase the initial height by 20 cm and each trial will have five iterations. The experiment will be concluded when six trials are completed.

Initial Height vs. Time to Resurface

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Trial** | **Initial Height** H / cm ∆H = ± 1.0 cm | **Average Initial Height** ∆H = ± 1.0 cm | **Time to Resurface** T / s ∆T = ± 0.01 s | **Average Time to Resurface** ∆T = ± 0.02 s |
| 1 | 20.0 | 20.0 | 0.04 | 0.05 |
| 20.0 | 0.05 |
| 20.0 | 0.05 |
| 20.0 | 0.06 |
| 20.0 | 0.05 |
| 2 | 40.0 | 40.0 | 0.05 | 0.06 |
| 40.0 | 0.07 |
| 40.0 | 0.06 |
| 40.0 | 0.05 |
| 40.0 | 0.06 |
| 3 | 60.0 | 60.0 | 0.05 | 0.05 |
| 60.0 | 0.06 |
| 60.0 | 0.07 |
| 60.0 | 0.05 |
| 60.0 | 0.04 |
| 4 | 80.0 | 80.0 | 0.07 | 0.06 |
| 80.0 | 0.05 |
| 80.0 | 0.06 |
| 80.0 | 0.06 |
| 80.0 | 0.05 |
| 5 | 100.0 | 100.0 | 0.06 | 0.06 |
| 100.0 | 0.07 |
| 100.0 | 0.05 |
| 100.0 | 0.06 |
| 100.0 | 0.05 |
| 6 | 120.0 | 120.0 | 0.06 | 0.06 |
| 120.0 | 0.07 |
| 120.0 | 0.05 |
| 120.0 | 0.07 |
| 120.0 | 0.07 |

The best fit line of this graph has a gradient of 0.0001. Due to the gradient's insignificant magnitude, I believe that the time of resurfacement is not affected by a change in the initial height. Using a linear fit line, I have an R2 value equal to 0.7112, which means that I have a correlation coefficient of 84.33%. This is statistically insignificant and gives me doubt about my data. As well, the y-intercept is 0.05 seconds above zero; and considering the consistency of the resurfacement time value, which is always around 0.05 s, I decided to discover what the resurfacement time would be if I dropped the ornament at 0 cm.

This graph, with the tested 0 cm initial height, has a gradient of 0.0001, which is the exact same value as the last graph. This leads me to believe once again that the time of resurface is not affected by a change in the initial height. The correlation coefficient 88.9%, which is statistically more accurate than the previous graph. This graph has reduced my doubt of the old graph because of the correlation coefficient. On this graph, the y-intercept is 0.05, which is the same as the previous graph and had confirmed my assumption that the time of resurface would be this value if the initial height were 0 cm. This makes sense because the ornament was still being fully submerged with a resurface, and the total time of this was the same as the other trials within the bounds of experimental error.

The best fit gradient is calculated to be 0.0001.

Calculating maximum and minimum gradients:

Maximum gradient = (0.08 – 0.03) / (121.0 – (-1.00)) = 4.11

Minimum gradient = (0.04 – 0.07) / (119.0 – 1.00) = -2.54

The gradient uncertainty would be 1/2(4.11 – (-2.54)) = 3.33.

Therefore the gradient is calculated to be **0.0001 ± 3.33.**

According to my data, there is appears to be no relationship between the time of resurface and a change in the initial height. Both of the graphs support this conclusion. Although both of the graphs both have a relatively low correlation coefficient, the best fit line was within the bound of experimental error; and with the fact that I was dealing with such small number, I believe there is a reasonable about of certainty to this conclusion of the relationship. All the trials support this because when I increased the height of which the ornament was dropped from, the time of resurface did not change. To account for random error, I have taken repeated measurements for each trial performed. To account for systematical errors, I had to do several test runs to accurately drop the ornament into the center of the container; for it did not drop in the same position, I would not have been able to get an accurate reading.

Throughout the data recording part of the experiment, I used a relatively not as capable video camera to record the experiment and later obtain the time of resurface value. This could have made my data was somewhat inaccurate because it to was the tool whereby I was obtaining my results from. To eliminate or minimize the possible errors presented from measuring the time, I used a video camera. But still, there may have been a random error with the usage of the which would have made some of my data inaccurate.

Since random error represents the largest uncontrolled uncertainty, I must modify my procedure to reduce or eliminate its effect. To fix this problem of accurately measuring time of resurface, I propose using multiple video cameras with a higher FPS (frames per second). By using multiple video cameras, you would be able to take the average of all the measurements and use that as your trial’s time of resurface. By using more capable cameras (such as a high-speed camera with a FPS of about 300) you would be able to more accurately obtain the actual time of the submersion and resurfacement thus giving you a more accurate time of resurface value. Combining these two, you would be able to minimize the amount of random errors that would be able to affect the results of the experiment.