Heading

Title

**Introduction**

**Purpose** To investigate freely falling objects in terms of time and distance of fall.

**Discussion**

Free fall is the condition when an object is only influenced by gravity, which is 9.8 m/s/s. In real life conditions, air resistance (drag as a form of friction) must be considered.

Average speed is the total distance an object moves divided by the time it takes to travel that distance. Instantaneous velocity is the speed at which an object is moving at a given point in time. For instance, when a ball falls from its highest point in the sky, the moment it strikes the ground one can calculate the instantaneous velocity of the ball.

One can calculate displacements if time and acceleration are known. If the initial velocity, acceleration, and time interval are known, the displacement of an object can be found by combining equations already used.

**d = vi t + ½ at2**

There are two terms in this equation. The first term, **vi t**, corresponds to the displacement of an object if it were moving with constant velocity, **vi**. The second term, **½ at2**, gives the displacement of an object starting from rest and moving with uniform acceleration.

The sum of these two terms, **vi t** and **½ at2**, gives the displacement of an object that starts with an initial velocity and accelerates uniformly. For an object that starts from rest, the equation reduces to: **d =** **½ at2**.

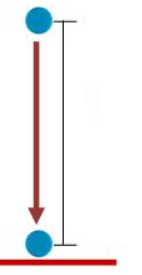
**Hypothesis**

If a ball is thrown vertically in the air, the higher it is thrown, then the greater its instantaneous velocity upon impact with the ground or surface.

**Materials** Stop Watch Tennis Ball Calculator

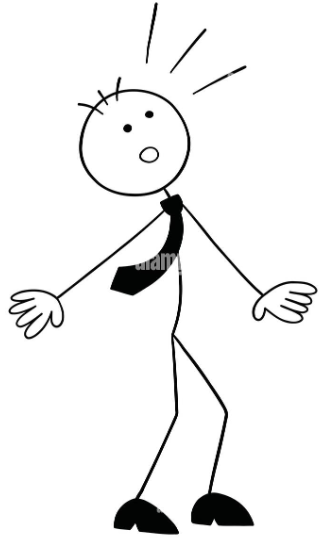
**Procedures**

1. It is helpful to have at least a partner for this lab to accomplish the following roles: timer, recorder, thrower, spotter.
2. Throw the tennis ball vertically as high as possible. Try NOT to throw it at any angle.
3. Time from the highest point the ball reaches until it strikes the ground (*to the nearest tenth of a second*).
4. Repeat for three trials.
5. Record all results in the data table.



Viewing from an angle works best.

Measure the time it takes to go from the highest point to the ground.



Hitting the Ground

Highest Point

**Calculations and Data:**

8. Record the times to the nearest TENTH of a second for all the throws in the chart below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Time 1st throw (s) | Time 2nd throw (s) | Time 3rd throw (s) | Average Time of 3 Trials (s) |
| Thrower 1 |  |  |  |  |
| Thrower 2 |  |  |  |  |
| Thrower 3 |  |  |  |  |

1. Calculate the distance (in meters) the ball fell from the highest point in the sky to the ground “USING THE AVERAGE TIME OF 3 TRIALS” from the chart above. SHOW WORK for at least one of your trials in the space provided and put the answer to the nearest TENTH:

**d = ½ g t2 or d = ½ a t2**

|  |  |  |
| --- | --- | --- |
|  | Average Time of 3 trials (s) | Distance the Ball Fell (m) |
| Thrower 1 |  |  |
| Thrower 2 |  |  |
| Thrower 3 |  |  |

1. Calculate the “instantaneous speed” of the ball at the point it hits the ground for each of the average times in the chart. SHOW WORK for at least one of the trials. Put all answers to the nearest TENTH.

**v = g t [velocity = gravity x average time]**

|  |  |  |
| --- | --- | --- |
|  | Average Time of 3 trials (s) | Velocity (m/s) at the ground |
| Thrower 1 |  |  |
| Thrower 2 |  |  |
| Thrower 3 |  |  |

**Conclusions and Questions**

1. Draw a vector diagram of this experiment.

2. What is the value of the acceleration of freely falling objects?

3. Compare the time it took for the ball to reach its highest point in the sky to the amount of time it took to fall to the ground from the highest point in the sky.

4. Distinguish between average speed and instantaneous speed. Give evidence from the lab to support your answer.

5. What is the relationship between the distance the tennis ball fell and the velocity it had when it hit the ground?

6. Name and explain some factors that could influence the time it took for the tennis ball to reach the ground.

7. Suppose you threw the tennis ball down from the cliff at 30 m/s. How fast would it be traveling in 3 seconds?

8. Compare the velocity of the ball leaving the person’s hand as they threw it vertically upward with the velocity of the ball the moment it hits the ground. Describe the overall time from the throw to the landing of the ball?

**Error**

There were a few sources of error for this investigation. First, it was difficult to precisely determine the highest point the ball reached in order to start the timer. Second, the person taking the time of the free fall subjectively started and stopped the timer and they may not have been accurate. Another consideration was the person throwing the ball in the air as mentioned in the first paragraph of this summary.

**Bibliography**

Physical Science, Week 18. *Class Notes, Module 9*. *Riesen, C*. Learning CTR Online, n.d. Web. 9 Sept. 2017. [www.learningctronline.com](http://www.learningctronline.com) .

Physical Science, Week 18. *“Free Fall Lab”, Riesen, C, Lab handout*. Learning CTR Online, n.d. Web. 9 Sept. 2017. [www.learningctronline.com](http://www.learningctronline.com) .

Wysession, M., Frank, D, and Yancopoulos, S.. Physical Science, Concepts in Action. Pearson Education, Inc., 2011. Upper Saddle River, New Jersey 07458. Print.

**ANSWERS**

**Calculations and Data:**

8. Record the times to the nearest TENTH of a second for all the throws in the chart below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Time 1st throw (s) | Time 2nd throw (s) | Time 3rd throw (s) | Average Time of 3 Trials (s) |
| Thrower 1 | 1.9 s | 2.0 s | 2.1 s | 2.0 s |
| Thrower 2 | 2.9 s | 3.1 s | 3.0 s | 3.0 s |
| Thrower 3 | 2.4 s | 2.6 s | 2.5 s | 2.5 s |

9. Calculate the distance (in meters) the ball fell from the highest point in the sky to the ground “USING THE AVERAGE TIME OF 3 TRIALS” from the chart above. SHOW WORK for at least one of your trials in the space provided and put the answer to the nearest TENTH:

**d = ½ g t2 or d = ½ a t2**

|  |  |  |
| --- | --- | --- |
|  | Average Time of 3 trials (s) | Distance the Ball Fell (m) |
| Thrower 1 | 2.0 s | 20.0 m |
| Thrower 2 | 3.0 s | 45.0 m |
| Thrower 3 | 2.5 s | 27.5 m |

d = ½ g t2 d = ½ (10.0 m/s2)(2.0 s)2 d = 5.0 x 4.0 = 20.0 m

10. Calculate the “instantaneous speed” of the ball at the point it hits the ground for each of the average times in the chart. SHOW WORK for at least one of the trials. Put all answers to the nearest TENTH.

**v = g t [velocity = gravity x average time]**

|  |  |  |
| --- | --- | --- |
|  | Average Time of 3 trials (s) | Velocity (m/s) at the ground |
| Thrower 1 | 2.0 s | 20.0 m/s |
| Thrower 2 | 3.0 s | 30.0 m/s |
| Thrower 3 | 2.5 s | 25.0 m/s |

v = g t v = (10.0 m/s2)(2.0 s) v = 20.0 m/s

**Conclusions and Questions**

**Hypothesis**

We proposed that the higher the ball is thrown vertically in the air, the greater its instantaneous velocity upon impact with the ground or surface. Based on our experimental results, we were correct. When the ball fell 2.0 s it struck the ground at 20.0 m/s compared to falling 3.0 s in which it struck the ground at 30.0 m/s.

**Analysis**

This lab was about free fall which is a physical state that occurs when an object is only influenced by gravity. Gravity is the force of attraction between two objects and is equal to -10.0 m/s2. Factors that influence free fall are air resistance and possibly the height at which the object falls. For instance, some students in this lab only threw the ball a short distance (2 – 3 m) in the air and it was difficult to get accurate times for the fall. We illustrated the free fall of a tennis ball using a vector diagram, containing magnitude and direction.

We also learned to distinguish average speed and instantaneous speed. Average speed is the total distance an object moves divided by the time it takes to travel that distance. You must include at least two speeds, whereas, instantaneous speed is speed at a given moment in time. In this lab, we did not have to calculate the average speed from the three trials, but it came out 25.0 m/s based on the three trials. We did calculate the instantaneous speed at which the ball was traveling when it hit the ground for one of the trials (20.0 m/s).

The speeds were a direct relationship to the distance that the tennis ball fell. This means that the greater the distance the ball fell, the greater the speed it was traveling when it hit the ground. In this lab, we observed this relationship because the distance increased from 20.0 m to 30.0 m and the velocity increased from 20.0 m/s to 30.0 m/s.

1. A vector diagram of this experiment would look like this:

dy = +20.0 m

dy = -20.0 m

*The vectors must have magnitude (as indicated by the distance, dy, and direction (as indicated by the arrows). Other vectors that could have been used would be velocity or time.*

2. The value of the acceleration of freely falling objects is -10 m/s/s.

3. The time it took for the ball to reach its highest point in the sky is the same compared to the amount of time it took to fall to the ground from the highest point in the sky. Since it took 2.0 seconds to fall from the highest point, it must have taken 2.0 seconds to reach that same height from the ground.

4 Average speed and instantaneous speed differ in the way they are determined. Average speed is the total distance an object moves divided by the time it takes to travel that distance. You must include at least two speeds, whereas, instantaneous speed is speed at a given moment in time. In this lab, we did not have to calculate the average speed from the three trials, but it came out 25.0 m/s based on the three trials. We did calculate the instantaneous speed at which the ball was traveling when it hit the ground for one of the trials (20.0 m/s).

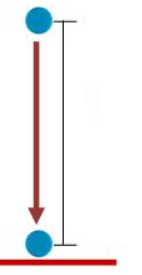
5. The distance the tennis ball fell and the velocity it had when it hit the ground shows a direct relationship. This means that the greater the distance the ball fell, the greater the speed it was traveling when it hit the ground. In this lab, we observed this relationship because the distance increased from 20.0 m to 30.0 m and the velocity increased from 20.0 m/s to 30.0 m/s.

6. Some factors that could influence the time it took for the tennis ball to reach the ground are air resistance, the height to which the ball was thrown, and the accuracy of the timer (did he/she really start when the ball reached its highest point and stop the moment it hit the ground?).

7. If one threw the tennis ball down from the cliff at 30 m/s it would travel 60 m/s in 3 seconds. This is determined using the equation: V = Vi + at, where “a” = gravity and Vi represents the initial velocity, 30 m/s.

V = Vi + at V = 30 m/s + (10.0 m/s2)(3.0 s)

8. The velocity of the ball leaving the person’s hand as they threw it vertically upward is the same as the velocity of the ball the moment it hits the ground. This is because the vertical component of distance and time do not change. Therefore, v = d/t is constant for both. (Assuming no air resistance). The overall time from the throw to the landing of the ball is 2t.



dy up = -dy down (opposite directions)

t up = t down … total time is t up + t down = 2t

v up = -v down (opposite directions)

dy