# Extended Practical Investigation - The Bouncing Ball

**Aim:**

Part 1: To drop a basketball from 2m and record the motion of the basketball from the 2m mark with the Go-Motion probe for 5 bounces.

Part 2: To drop a tennis ball from 90cm and record the motion of the tennis ball from the 90cm mark with the Go-Motion probe for 5 bounces.

Part 3: To create a displacement-time and velocity time-graph for each of the ball's motion, and to calculate and graph the gravitational potential, kinetic energy and total mechanical energy using the recorded data.

Part 4: To calculate the percentage of energy loss of the motion of the basketball and tennis for each bounce and devise a formula to calculate the height after 'n' bounces

**Introduction**

Energy is required to change an object's motion. All objects have energy associated with it, for example, a ball has mechanical energy due to its motion or position. In agreement with the law of conservation of energy, energy should never be loss. When we look at the motion of a bouncing ball however, it eventually stops moving. The energy has not disappeared but transformed.

When you bounce a ball, the maximum height achieved is always the highest. The bounces after that achieve less height than the first bounce, and every subsequent jump is even less. This is because of the transformation of energy in the motion of the ball. The ball experiences air resistance, some of the energy is converted to sound and heat, while some energy is absorbed into the ground.

As the ball gains height, it's energy is converted into gravitational potential energy, which is calculated by **E=mgh** where E is energy in joules, m is mass in kilograms, g is force of gravity (9.8ms-2) in this experiment and h is height in metres) As the ball is moving faster, it's potential energy is transformed into kinetic energy, which is calculated by the formula **E=1/2\*mv2**where E is energy in joules, m is mass in kilograms and v is velocity in ms-1. While the ball is in air, the energy is conserved, called the total mechanical energy. This is the sum of the potential and kinetic energy.

Whenever the ball makes contact with the ground however, a percentage of the TME is transferred to the ground. The TME of the ball after the bounce is less than the TME before the bounce. It is for this reason that bouncing balls never return to their original height and eventually stop bouncing.

In this experiment, the energy loss and motion of two different balls will be studied. The first ball, the basketball (its shape and size) will be the dependent variable and the constant height of 2 metres will be the independent variable. The second ball, the tennis ball (its shape and size) and its bounces will be the other dependent variable and the height of 0.9 metres will be the independent variable. Other variables such as material that the ground is made of can affect the bouncing, but this will be kept constant so it should not affect the results.

**Hypothesis**

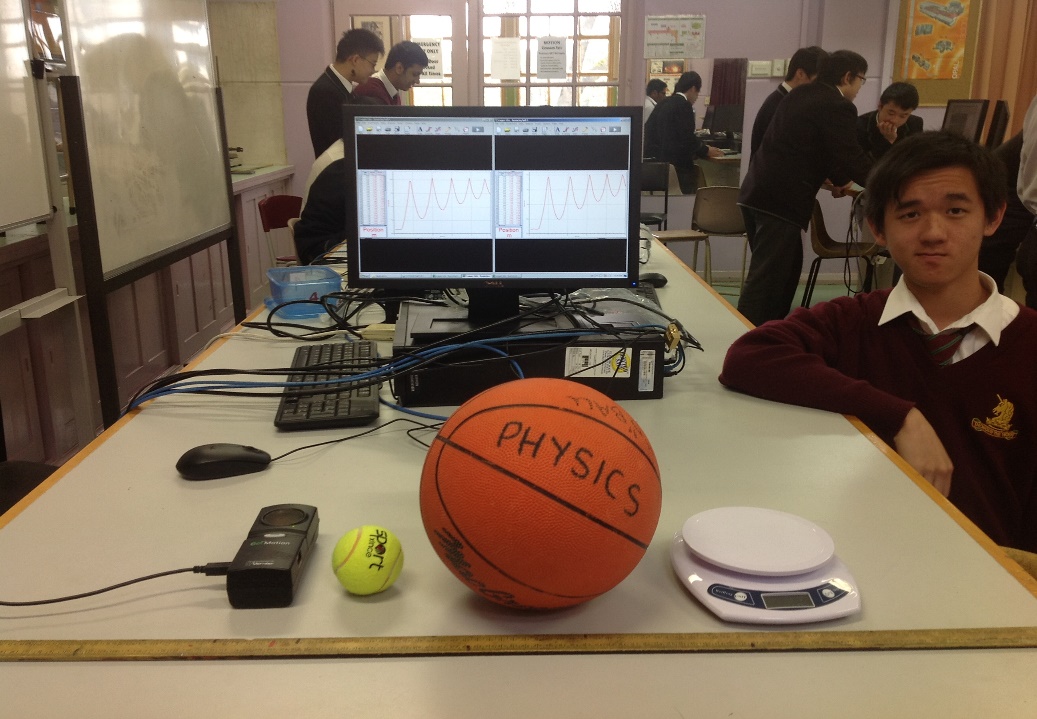
Part 1: and Part 2: The displacement of the basketball and tennis ball from the ground will decrease with each bounce with the ball finally stopping. The basketball will bounce higher and for longer than the tennis ball.

Part 3: The displacement-time graph will be parabolic for both balls. There will be an inverse relationship for the gravitational potential energy and kinetic energy where an increase in one will lead to a decrease in the other. The total of these two graphs will amount to the total mechanical energy for each bounce. After each bounce, the total mechanical energy will decrease.

Part 4: The percentage of energy loss of the motion of the basketball will be different to the percentage of energy loss of the tennis ball. The percentage loss will be constant for each bounce.

**Equipment**

* 1 basketball - This will be one of the main variables
* 1 tennis ball - This will be one of the main variables
* 1 scale - This will be used to measure the mass of each of the balls
* 1 Motion-Go probe - This will be used to record the motion of the ball as it bounces
* 1 measuring tape - This will be used to measure the distances from where the ball will drop
* 1 computer with excel - This will be used to use the data to calculate energy with formulas



**Method**

Remember this experiment should be conducted in a safe environment. The persons conducting this experiment should make sure wires are not in a position where someone can trip.

Part 1:

1. Measure 2m from the floor with the measuring tape
2. Connect the Motion-Go sensor to the computer
3. Open the recording program
4. Place the Motion-Go sensor at the 2 metre line
5. Weigh the basketball with the scales and
6. Place the basketball directly under the Motion - Go sensor
7. Drop the basketball (making sure no horizontal force acts on it to make it easier)
8. Observe the basketball bouncing and make sure it is properly graphed for five bounces on the computer program (should look similar to Fig. 1).



Figure 1 - A normal 5 bounce graph

1. Repeat steps 4-8 until you gather at least ten trials of data
2. Tabulate the data

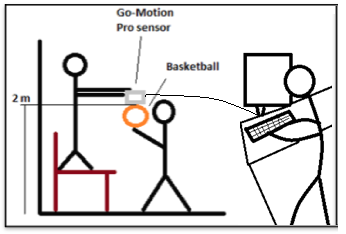


Figure 2 - The experiment setup for Part

To achieve a height of 2 metres, a chair or table may be used to help achieve the height. Take care that the object you use to increase your height is stable before climbing on

Part 2:

1. Measure 90 cm from the ground (the same place as part 1) with the measuring tape
2. Place the Go-Motion sensor at the 90cm line
3. Weigh the tennis ball with the scales and record the mass
4. Place the tennis ball directly under the Motion-Go sensor
5. Drop the tennis ball (making sure no horizontal force acts on it to make it easier)
6. Observe the tennis ball bouncing and make sure it is properly graphed for five bounces on the computer program (should look similar to Fig. 1).
7. Repeat steps 13-17 until you gather at least ten trials of data
8. Tabulate the data

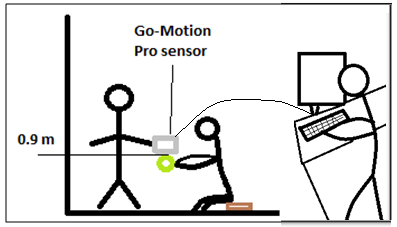


Figure 3 - The experiment setup for Part 2

Part 3:

1. Using the tables from Part 1 and Part 2, create a table of average values for the displacement and velocity of each ball
2. Use the average table to create a graph of displacement -time for each ball, making sure positive velocity is in the upwards direction

Part 4:

1. Input the formula E=1/2mv2 for kinetic energy and E=mgh for gravitational potential energy in the excel document
2. Input the formula Egravity+Ekinetic= total mechanical energy
3. Calculate the percentage of change in total mechanical energy with each bounce

**Results**

There are ten sets of data for each trial of the basketball bounce and tennis ball bounce and within this document is the average of the ten trials for both the basketball and the tennis ball. Tennis ball has less data due to it bouncing for a considerably shorter time

The uncertainty of the height of the ball and displacement is ± 0.05 cm.

**Basketball Data**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Time** | **Displacement from sensor** | **Velocity (downward positive)** | **Height of basketball from ground** | **Velocity**  **(upward positive)** | **KE** | **GPE** | **TME** |
| 0.05 | 1.75 | -1.02 | 0.25 | 1.02 | 211.38 | 1009.14 | 1220.52 |
| 0.10 | 1.52 | -3.28 | 0.48 | 3.28 | 2192.08 | 1918.90 | 4110.98 |
| 0.15 | 1.31 | -3.68 | 0.69 | 3.68 | 2764.38 | 2743.91 | 5508.29 |
| 0.20 | 1.13 | -3.43 | 0.87 | 3.43 | 2395.76 | 3478.89 | 5874.65 |
| 0.25 | 0.97 | -2.95 | 1.03 | 2.95 | 1768.82 | 4117.32 | 5886.13 |
| 0.30 | 0.84 | -2.47 | 1.16 | 2.47 | 1244.85 | 4653.73 | 5898.58 |
| 0.35 | 0.72 | -2.01 | 1.28 | 2.01 | 821.76 | 5102.03 | 5923.79 |
| 0.40 | 0.63 | -1.53 | 1.37 | 1.53 | 479.83 | 5458.44 | 5938.27 |
| 0.45 | 0.57 | -1.05 | 1.43 | 1.05 | 224.92 | 5717.34 | 5942.26 |
| 0.50 | 0.53 | -0.57 | 1.47 | 0.57 | 65.42 | 5877.93 | 5943.35 |
| 0.55 | 0.51 | -0.09 | 1.49 | 0.09 | 1.63 | 5942.12 | 5943.75 |
| 0.60 | 0.52 | 0.39 | 1.48 | -0.39 | 30.36 | 5913.34 | 5943.70 |
| 0.65 | 0.55 | 0.87 | 1.45 | -0.87 | 152.76 | 5788.85 | 5941.61 |
| 0.70 | 0.61 | 1.35 | 1.39 | -1.35 | 371.67 | 5568.30 | 5939.97 |
| 0.75 | 0.69 | 1.84 | 1.31 | -1.84 | 688.34 | 5249.81 | 5938.15 |
| 0.80 | 0.79 | 2.32 | 1.21 | -2.32 | 1101.36 | 4833.69 | 5935.05 |
| 0.85 | 0.92 | 2.81 | 1.08 | -2.81 | 1608.32 | 4320.24 | 5928.56 |
| 0.90 | 1.07 | 3.30 | 0.93 | -3.30 | 2216.01 | 3713.51 | 5929.51 |
| 0.95 | 1.25 | 3.66 | 0.75 | -3.66 | 2734.47 | 3000.70 | 5735.17 |
| 1.00 | 1.45 | 3.51 | 0.55 | -3.51 | 2506.23 | 2193.97 | 4700.19 |
| 1.05 | 1.67 | 1.96 | 0.33 | -1.96 | 779.84 | 1329.84 | 2109.69 |
| 1.10 | 1.72 | -0.84 | 0.28 | 0.84 | 145.55 | 1137.25 | 1282.81 |
| 1.15 | 1.53 | -2.74 | 0.47 | 2.74 | 1533.57 | 1866.61 | 3400.18 |
| 1.20 | 1.36 | -3.04 | 0.64 | 3.04 | 1889.68 | 2557.95 | 4447.63 |
| 1.25 | 1.21 | -2.74 | 0.79 | 2.74 | 1534.03 | 3155.74 | 4689.77 |
| 1.30 | 1.08 | -2.27 | 0.92 | 2.27 | 1051.89 | 3658.23 | 4710.12 |
| 1.35 | 0.98 | -1.79 | 1.02 | 1.79 | 651.90 | 4064.04 | 4715.94 |
| 1.40 | 0.91 | -1.30 | 1.09 | 1.30 | 345.25 | 4373.65 | 4718.91 |
| 1.45 | 0.85 | -0.82 | 1.15 | 0.82 | 135.93 | 4583.72 | 4719.65 |
| 1.50 | 0.82 | -0.34 | 1.18 | 0.34 | 23.71 | 4697.82 | 4721.53 |
| 1.55 | 0.82 | 0.14 | 1.18 | -0.14 | 3.72 | 4720.46 | 4724.18 |
| 1.60 | 0.84 | 0.62 | 1.16 | -0.62 | 77.21 | 4644.92 | 4722.13 |
| 1.65 | 0.88 | 1.09 | 1.12 | -1.09 | 242.47 | 4472.80 | 4715.27 |
| 1.70 | 0.95 | 1.57 | 1.05 | -1.57 | 505.70 | 4210.94 | 4716.64 |
| 1.75 | 1.04 | 2.07 | 0.96 | -2.07 | 876.03 | 3846.54 | 4722.57 |
| 1.80 | 1.15 | 2.56 | 0.85 | -2.56 | 1340.97 | 3380.86 | 4721.83 |
| 1.85 | 1.29 | 2.97 | 0.71 | -2.97 | 1803.50 | 2820.17 | 4623.67 |
| 1.90 | 1.46 | 3.04 | 0.54 | -3.04 | 1878.73 | 2162.88 | 4041.62 |
| 1.95 | 1.65 | 2.01 | 0.35 | -2.01 | 827.21 | 1406.43 | 2233.64 |
| 2.00 | 1.73 | -0.21 | 0.27 | 0.21 | 8.92 | 1098.93 | 1107.85 |
| 2.05 | 1.60 | -2.03 | 0.40 | 2.03 | 837.91 | 1580.19 | 2418.10 |
| 2.10 | 1.45 | -2.50 | 0.55 | 2.50 | 1278.82 | 2187.12 | 3465.94 |
| 2.15 | 1.33 | -2.28 | 0.67 | 2.28 | 1055.65 | 2688.18 | 3743.84 |
| 2.20 | 1.22 | -1.84 | 0.78 | 1.84 | 690.81 | 3106.52 | 3797.32 |
| 2.25 | 1.14 | -1.36 | 0.86 | 1.36 | 378.24 | 3427.04 | 3805.28 |
| 2.30 | 1.09 | -0.88 | 0.91 | 0.88 | 157.31 | 3651.93 | 3809.24 |
| 2.35 | 1.05 | -0.40 | 0.95 | 0.40 | 32.43 | 3776.88 | 3809.30 |
| 2.40 | 1.05 | 0.07 | 0.95 | -0.07 | 1.12 | 3809.94 | 3811.07 |
| 2.45 | 1.06 | 0.55 | 0.94 | -0.55 | 61.55 | 3747.81 | 3809.35 |
| 2.50 | 1.10 | 1.03 | 0.90 | -1.03 | 215.09 | 3590.85 | 3805.95 |
| 2.55 | 1.16 | 1.51 | 0.84 | -1.51 | 464.01 | 3338.22 | 3802.23 |
| 2.60 | 1.25 | 1.98 | 0.75 | -1.98 | 798.90 | 2987.44 | 3786.35 |
| 2.65 | 1.36 | 2.37 | 0.64 | -2.37 | 1140.51 | 2542.25 | 3682.76 |
| 2.70 | 1.50 | 2.41 | 0.50 | -2.41 | 1188.57 | 2005.51 | 3194.07 |
| 2.75 | 1.64 | 1.64 | 0.36 | -1.64 | 548.23 | 1428.42 | 1976.66 |
| 2.80 | 1.71 | -0.10 | 0.29 | 0.10 | 2.00 | 1144.42 | 1146.42 |
| 2.85 | 1.62 | -1.58 | 0.38 | 1.58 | 512.18 | 1523.73 | 2035.91 |
| 2.90 | 1.50 | -2.01 | 0.50 | 2.01 | 824.47 | 1997.15 | 2821.62 |
| 2.95 | 1.39 | -1.83 | 0.61 | 1.83 | 684.02 | 2421.68 | 3105.70 |
| 3.00 | 1.31 | -1.41 | 0.69 | 1.41 | 405.97 | 2752.34 | 3158.31 |
| 3.05 | 1.25 | -0.94 | 0.75 | 0.94 | 181.84 | 2988.28 | 3170.12 |
| 3.10 | 1.22 | -0.47 | 0.78 | 0.47 | 45.35 | 3129.74 | 3175.09 |
| 3.15 | 1.21 | 0.00 | 0.79 | 0.00 | 0.00 | 3177.06 | 3177.06 |
| 3.20 | 1.22 | 0.47 | 0.78 | -0.47 | 45.78 | 3127.77 | 3173.55 |
| 3.25 | 1.25 | 0.95 | 0.75 | -0.95 | 184.24 | 2988.95 | 3173.20 |
| 3.30 | 1.31 | 1.42 | 0.69 | -1.42 | 411.72 | 2748.20 | 3159.92 |
| 3.35 | 1.40 | 1.83 | 0.60 | -1.83 | 679.20 | 2417.21 | 3096.41 |
| 3.40 | 1.50 | 1.96 | 0.50 | -1.96 | 782.17 | 1987.31 | 2769.49 |
| 3.45 | 1.62 | 1.46 | 0.38 | -1.46 | 432.99 | 1522.03 | 1955.02 |
| 3.50 | 1.69 | 0.19 | 0.31 | -0.19 | 7.45 | 1247.38 | 1254.82 |
| 3.55 | 1.63 | -1.03 | 0.37 | 1.03 | 214.50 | 1458.80 | 1673.30 |
| 3.60 | 1.55 | -1.54 | 0.45 | 1.54 | 484.15 | 1800.10 | 2284.25 |
| 3.65 | 1.46 | -1.48 | 0.54 | 1.48 | 445.27 | 2173.05 | 2618.31 |
| 3.70 | 1.39 | -1.09 | 0.61 | 1.09 | 240.39 | 2437.85 | 2678.24 |
| 3.75 | 1.35 | -0.64 | 0.65 | 0.64 | 83.75 | 2607.13 | 2690.88 |
| 3.80 | 1.33 | -0.19 | 0.67 | 0.19 | 7.05 | 2693.05 | 2700.10 |
| 3.85 | 1.33 | 0.28 | 0.67 | -0.28 | 15.93 | 2684.10 | 2700.03 |
| 3.90 | 1.35 | 0.74 | 0.65 | -0.74 | 112.21 | 2580.56 | 2692.77 |
| 3.95 | 1.40 | 1.22 | 0.60 | -1.22 | 302.90 | 2389.48 | 2692.38 |
| 4.00 | 1.48 | 1.63 | 0.52 | -1.63 | 543.79 | 2092.53 | 0.00 |

**Tennis Ball Data**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Time** | **Displacement from the sensor** | **Velocity (downward positive)** | **Displacement from ground** | **Velocity (upward positive)** | **KE** | **GPE** | **TME** |
| 0.05 | 0.8509 | -0.7725 | 0.0491 | 0.7725 | 0.0167 | 0.0269 | 0.0436 |
| 0.10 | 0.7509 | -1.8127 | 0.1491 | 1.8127 | 0.0920 | 0.0818 | 0.1738 |
| 0.15 | 0.6319 | -1.9210 | 0.2681 | 1.9210 | 0.1033 | 0.1471 | 0.2505 |
| 0.20 | 0.5392 | -1.6005 | 0.3608 | 1.6005 | 0.0717 | 0.1980 | 0.2697 |
| 0.25 | 0.4698 | -1.1296 | 0.4302 | 1.1296 | 0.0357 | 0.2361 | 0.2718 |
| 0.30 | 0.4259 | -0.6318 | 0.4741 | 0.6318 | 0.0112 | 0.2602 | 0.2713 |
| 0.35 | 0.4066 | -0.1357 | 0.4934 | 0.1357 | 0.0005 | 0.2708 | 0.2713 |
| 0.40 | 0.4129 | 0.3535 | 0.4871 | -0.3535 | 0.0035 | 0.2673 | 0.2708 |
| 0.45 | 0.4420 | 0.8433 | 0.4580 | -0.8433 | 0.0199 | 0.2514 | 0.2713 |
| 0.50 | 0.4962 | 1.3522 | 0.4038 | -1.3522 | 0.0512 | 0.2216 | 0.2728 |
| 0.55 | 0.5772 | 1.7919 | 0.3228 | -1.7919 | 0.0899 | 0.1772 | 0.2671 |
| 0.60 | 0.6823 | 1.9379 | 0.2177 | -1.9379 | 0.1052 | 0.1195 | 0.2246 |
| 0.65 | 0.8156 | 1.1813 | 0.0844 | -1.1813 | 0.0391 | 0.0463 | 0.0854 |
| 0.70 | 0.8424 | -0.3305 | 0.0576 | 0.3305 | 0.0031 | 0.0316 | 0.0347 |
| 0.75 | 0.7457 | -1.1820 | 0.1543 | 1.1820 | 0.0391 | 0.0847 | 0.1238 |
| 0.80 | 0.6760 | -1.0794 | 0.2240 | 1.0794 | 0.0326 | 0.1230 | 0.1556 |
| 0.85 | 0.6300 | -0.6663 | 0.2700 | 0.6663 | 0.0124 | 0.1482 | 0.1606 |
| 0.90 | 0.6093 | -0.1719 | 0.2907 | 0.1719 | 0.0008 | 0.1595 | 0.1603 |
| 0.95 | 0.6131 | 0.3170 | 0.2869 | -0.3170 | 0.0028 | 0.1574 | 0.1602 |
| 1.00 | 0.6404 | 0.8128 | 0.2596 | -0.8128 | 0.0185 | 0.1425 | 0.1610 |
| 1.05 | 0.6950 | 1.2045 | 0.2050 | -1.2045 | 0.0406 | 0.1125 | 0.1531 |
| 1.10 | 0.7725 | 1.2530 | 0.1275 | -1.2530 | 0.0440 | 0.0699 | 0.1139 |
| 1.15 | 0.8669 | 0.4322 | 0.0331 | -0.4322 | 0.0052 | 0.0182 | 0.0234 |
| 1.20 | 0.8265 | -0.5794 | 0.0735 | 0.5794 | 0.0094 | 0.0404 | 0.0498 |
| 1.25 | 0.7629 | -0.7574 | 0.1371 | 0.7574 | 0.0161 | 0.0752 | 0.0913 |
| 1.30 | 0.7293 | -0.4382 | 0.1707 | 0.4382 | 0.0054 | 0.0937 | 0.0991 |
| 1.35 | 0.7178 | 0.0251 | 0.1822 | -0.0251 | 0.0000 | 0.1000 | 0.1000 |
| 1.40 | 0.7310 | 0.4912 | 0.1690 | -0.4912 | 0.0068 | 0.0928 | 0.0995 |
| 1.45 | 0.7701 | 0.8053 | 0.1299 | -0.8053 | 0.0182 | 0.0713 | 0.0894 |
| 1.50 | 0.8349 | 0.6324 | 0.0651 | -0.6324 | 0.0112 | 0.0357 | 0.0469 |
| 1.55 | 0.8601 | -0.0293 | 0.0399 | 0.0293 | 0.0000 | 0.0219 | 0.0219 |
| 1.60 | 0.8172 | -0.4274 | 0.0828 | 0.4274 | 0.0051 | 0.0454 | 0.0505 |
| 1.65 | 0.7878 | -0.2516 | 0.1122 | 0.2516 | 0.0018 | 0.0616 | 0.0633 |
| 1.70 | 0.7839 | 0.1349 | 0.1161 | -0.1349 | 0.0005 | 0.0637 | 0.0642 |
| 1.75 | 0.8039 | 0.4610 | 0.0961 | -0.4610 | 0.0060 | 0.0527 | 0.0587 |
| 1.80 | 0.8504 | 0.3805 | 0.0496 | -0.3805 | 0.0041 | 0.0272 | 0.0313 |
| 1.85 | 0.8584 | -0.0051 | 0.0416 | 0.0051 | 0.0000 | 0.0228 | 0.0228 |
| 1.90 | 0.8366 | -0.1584 | 0.0634 | 0.1584 | 0.0007 | 0.0348 | 0.0355 |
| 1.95 | 0.8243 | 0.0219 | 0.0757 | -0.0219 | 0.0000 | 0.0416 | 0.0416 |
| 2.00 | 0.8381 | 0.2333 | 0.0619 | -0.2333 | 0.0015 | 0.0340 | 0.0355 |

**Analysis & Discussion (some graphs in this section are not as clear, so look in the excel document)**

**Graph 1**

By inspection of the graph, after each bounce the peak height (green) decreases. The time of contact with the ground (red) occurs at shorter intervals after each bounce. The shape of this graph is parabolic because the ball quickly accelerates towards the ground, bounces up again, stops momentarily at the peak heights and accelerates towards the ground again.

**Graph 2**

On examination of the graph, the shape of the graph is diagonally linear, stops when the ball makes contact with the ground (orange), and is repeated five times. The constant gradient indicates there is a constant acceleration due to gravity. A positive velocity indicates velocity in the upwards direction. The sudden jump from negative to positive occurs because when the ball bounces, its direction changes also changing the velocity. The graph shows the ball slowing down after each bounce, which can be attributed to energy transfer to the ground.

**Graph 3**

By inspection of the graph, after each bounce the peak height (green) decreases. The time of contact with the ground (red) occurs at shorter intervals after each bounce. The shape of this graph is parabolic because the ball quickly accelerates towards the ground, bounces up again, stops momentarily at the peak heights and accelerates towards the ground again. The peak height achieved by the tennis ball is much smaller than that of the basketball, and the time of the five bounces is much shorter.

**Graph 4**

A positive velocity indicates velocity in the upwards direction. The sudden jump from negative to positive occurs because when the ball bounces, its direction changes also changing the velocity. The graph shows the ball slowing down after each bounce, which can be attributed to energy transfer to the ground. This all happens in a shorter timeframe than that of the basketball.

**Graph 5 (circles are in a strange position otherwise it would cover some data, read them vertically)**

From the graph, it is clear that the kinetic energy and gravitational potential energy has an inverse relationship, as a high gravitational potential energy results in a low kinetic energy at a certain time. The time whenever the ball makes contact with the ground is denoted in the gray circle. During each individual bounce, the TME is generally constant, but each subsequent bounce makes the TME decrease. The shape of the kinetic energy is a minimum turning point parabolic shape and the gravitational potential energy is a maximum turning point parabolic shape. The shape of the TME is generally linear and decreases in energy with each bounce.

Working out for % loss of TME after bounces:

1-(4690/5891) \* 100 = 20.38% loss between first and second bounce (79.62% retained)

1-(3760/4690) \* 100 = 19.83% loss between second and third bounce (80.17% retained)

1-(3154/) \* 100 = 16.12% loss between third and fourth bounce (83.88% retained)

1-(4690/5891) \* 100 = 15.16% loss between fourth and fifth bounce (84.84% retained)

**So the formula is roughly: height=height original \* 0.80^number of ball bounces**

Testing it out with peak heights of the fifth bounce is 0.67m:

Height =2\*(0.8)^5= 0.6554 metres, which is pretty close to 0.67 metres

**Graph 6 (circles are in a strange position otherwise it would cover some data, read them vertically)**

From the graph, it is clear that the kinetic energy and gravitational potential energy has an inverse relationship, as a high gravitational potential energy results in a low kinetic energy at a certain time. The time whenever the ball makes contact with the ground is denoted in the gray circle. During each individual bounce, the TME is generally constant, but each subsequent bounce makes the TME decrease. The shape of the kinetic energy is a minimum turning point parabolic shape and the gravitational potential energy is a maximum turning point parabolic shape. The shape of the TME is generally linear, but starts getting unorderly at the latter bounces. This can be attributed to the difficulty of obtaining data from the instrument due to the extremely small bounces of the tennis ball.

Working out for % loss of TME after bounces:

1-(0.16/0.27) \* 100 = 40.98% loss between first and second bounce (59.02% retained)

1-(0.1/0.16) \* 100 = 39.51% loss between second and third bounce (60.49% retained)

1-(0.06/0.1) \* 100 = 38.25% loss between third and fourth bounce (61.75% retained)

1-(0.04/0.06) \* 100 = 36.99% loss between fourth and fifth bounce (73.01% retained)

**So the formula is roughly: height=height original \* 0.60^number of ball bounces**

Testing it out with peak heights of the fifth bounce is 0.0757m:

Height =0.9\*(0.6)^5= 0.6554 metres, which is pretty close to 0.07 metres

**Conclusion**

The displacement of the basketball and tennis ball from the ground will decrease with each bounce is supported by the data. The basketball did bounce higher than the tennis ball. There is an inverse relationship for the gravitational potential energy and kinetic energy where an increase in one will lead to a decrease in the other. The total of these two added up to the total mechanical energy for each bounce. After each bounce, the total mechanical energy decreased as the energy was transformed in heat and sound and transferred into the ground. The percentage of energy loss of the motion of the basketball is different to the percentage of energy loss of the tennis ball. The percentage loss slightly decreased after every bounce.

**Evaluation**

Throughout this experiment many errors could have accumulated. To make sure the data is more accurate, further repetitions of the bounces for performed for each ball. Precision was limited because the ruler had 'mm' markings. Because the ruler had 'mm' markings, the uncertainty of the measurements was ± 0.05 cm. When the experiment was conducted, there was a lot of trouble at actually graphing the data as the ball bounced, as it would move slightly horizontal. To fix this we had to move the sensor to follow the horizontal motion of the ball, which could have changed the height the sensor was above from the ground. The motion of the tennis was especially difficult to deal with; as it was so small the sensor sometimes lost contact with it. This resulted in data that was not as great as that of the basketball which was much easier to record. Due to the instrument we were using to record the data, the initial velocity value was different for every trial, so the TME did not add up for the first few points. To make sure the extraneous variables were constant, we conducted the experiment in the same area for all trials, so factors such as a different floor won't change how high the ball bounces. To improve on this experiment in the future, further repetitions and the use of a bouncier or bigger ball will make it much easier to record data.

**Acknowledgements**

Thanks to Richard Lam for collecting all of the results and averaging them in excel.

Thanks to Victor Nguyentat for helping us conduct the experiment by dropping the ball for us.

The main book source used was Heinemann Physics 11 (3rd edition) for the theory used to hypothesize this experiment.

Other sources include the website <http://www.physicsforums.com/showthread.php?t=240378>, which helped me confirm if my graphs for the bouncing ball were accurate.