Conclusion and Evaluation

This experiment confirms the relationship between the pressure of a soccer ball and the rebound height of the ball. I also investigated if the surface which the ball bounced on affects the rebound height. The data I have collected shows the same relationship for all three sizes of soccer balls. For grass and stone, the rebound height increased as the pressure increase. A linear trendline was used to fit the data. When the ball bounced on dirt, all three sizes responded the same way to a change in pressure. At the highest and lowest pressure, the rebound height was 0 except the size three ball rebounded 1cm when the pressure was 2 lbs. As the pressure increased by 2 lbs. the rebound high increased approximately 12cm. This was the maximum height reached by the ball when it bounced on dirt. As the pressure increased from 4 lbs. to 10 lbs. the rebound height decreased linearly.

EV And what is the relationship?

EV More can be said here.

When the soccer balls were dropped with the same pressure on the three different surfaces, the rebound height was the highest with the stone, followed by the grass and then the dirt. The rebound height was higher with the stone than the grass because there is some grass between the ball and the grass. Although the ball was not rolling on the grass, there is friction as the ball falls vertically through the blades of grass. As the ball falls on the grass the blades bend out to the side from the weight of the ball. This is evident when you look at the grass after the ball hit the ground; you can see an indent in the grass. The friction between the stone and the soccer ball is negligible in comparison with the friction presented by the grass. The ball's higher rebound height on the stone is also due to the compactness of the different materials. The stone is a much denser than the grass which means the ball deforms more as it hits the stone causing it to lose less energy when it rebounds. The grass is cushioning the ball as it hits the ground which causes the rebound height to be reduced.

EV This is correct, but hardly scientific. More thought is needed.

EV Where is the argument that friction makes the difference here?
"Cushioning" is not friction but related to impulse.

When the ball bounced on dirt at low pressure our results were expected, the ball reached a very low rebound height. As the pressure increased the ball started to bounce higher, again this is what I expected. The results then veered away from my hypothesis as I continued to increase

the pressure. When the pressure reached about 6 lbs. the rebound high started to decrease again. This can be seen in graph 6. I think that this trend was observed because as the pressure increased, the ball became firmer. When the ball became firmer it hit the ground with a greater power. This caused a bigger indent in the dirt (since it was soft) which cushioned the ball.

If energy is never created or destroyed, why do some balls bounce higher than others if they are dropped from the same height? Since they are dropped from the same height, they have the same amount of energy. My conclusion is that when an under inflated ball hits the ground, the ball is more deformed than when an over inflated ball hits the ground. When the ball is deformed to a large magnitude, a larger portion of the surface hits the ground. This means that more energy is transferred into the ground. Also since there are fewer gas molecules in the ball, it is harder for the ball to regain its original shape. When the ball deforms the area inside the ball is essentially smaller. This means that the air molecules are colliding with the side of the ball more frequently causing the ball to regain its shape. When the ball is regaining its shape and the area increases, the number of collisions with the surface of the ball decreases. This means that there are weaker forces to 'push' the ball off the ground. With a high pressure the number of molecules inside the ball is greater. This means that as the ball deforms the collisions between the molecules and the soccer ball are more powerful and at a greater frequency. This causes the ball to rebound faster and with a greater magnitude.

EV and **C** If only they have the same mass too. The student is rambling too much and needs to get to the key points.

EV Now the student is thinking. But again, this needs to be related more to the analysis of the data, not just theory.

The dirt was not very hard packed so it 'cushioned' the balls as they fell. This was a source of energy loss. Due to the 'cushion' effect of the dirt, the rebound height was significantly lower than stone and grass. This can be seen in graph 1, graph 2 and graph 3.

Besides energy loss to sound, heat and friction as the ball hit the surface, there was energy loss due to air resistance. When the ball fell from its initial height I assumed that all the energy was transferred to kinetic but in fact some energy is transferred to the air. Therefore it is not possible to reach the initial height when it rebounds back up, even if no energy was transferred to sound, heat or friction on the ground.

The unevenness of the surfaces also caused some problems with the data collection. The ball did not always bounce in a perfectly vertical manner. It would rebound on an angle causing the motion detection to record incorrect values. Since the ball was traveling at an angle, the vertical component of it was smaller than it would have been if it bounced straight up.

EV The student is aware of some of the issues, but again the comments are too qualitative and not related back to the experimental data.

When processing my data I was only concerned with the first rebound height, not the successive bounces. The data for the first rebound height seemed to follow a general trend and the trials seemed to be precise but I don't think the actually values for the rebound height are accurate. Some trials show that the second rebound is higher than the first rebound. From

qualitative observations I know that this did not occur. This confirms that the motion sensor was not always collecting the maximum height of the rebound. This will be discussed in further detail when I explain improvements to the lab.

EV This may be correct but what is the sampling rate? One could easily improve this aspect of the data collection (as mentioned a few paragraphs later but should have been appreciated when designing the investigation).

To improve this investigation I could ensure all the balls were made from the same brand and made from the same material. The material of the soccer balls used in this experiment were all different. The different materials have different properties that could have made them react differently on the three surfaces. The material of the size 3 soccer ball seemed worn in comparison to the size 1 and size 5 soccer balls.

EV This should have been a control variable, but how it improve things is not suggested.

Next time I would have used a dirt surface that was harder packed. Since the dirt was lightly packed every trial made the dirt harder packed for the next trial. This means that the later trials would essentially be bouncing on a different surface because the dirt would become less 'absorbent' as the ground compresses.

To improve my investigation I would set LabPro to collect data from the motion sensor every 0.01 seconds instead of every 0.05 seconds. Since the ball bounces so quickly, it could have reached hit the ground and start bouncing back up before data is collected for its maximum displacement. If the data was taken every 0.01 seconds our data would be more precise to the real displacement of the ball.

To further investigate the optimal conditions for a soccer ball I could explore the relationship between the design in the leather and rebound height. Different balls have different aerodynamics due to the different design of the ball. Some are made out of hexagons and pentagons (the traditional way) while others are made with irregular shapes. The aerodynamics of the ball affects the velocity that the ball has when it hits the ground. I would expect that at different velocities the rebound height would change.

EV and **C** What does this mean? More waffle does not help the student.