Exploring the relationship between the pressure of the ball and coefficient of restitution.

EX and **C** The title does not describe the entire investigation. The student lacks focus.

When I started thinking about possible investigations I knew I wanted to create a lab that was related to sports. After a number of ideas, I thought that changing the pressure of the ball would be a good independent variable and the rebound height of the dropped ball would be a good dependent variable. This was very interesting to me because I had just started basketball season and it's always a struggle finding a good ball to use at practice. Some balls are too bouncy and others are under inflated. My sister and I are also very particular about our soccer balls. When the ball is over inflated it's harder to control, and when it is under inflated the trajectory of the ball is altered.

PE The student clearly has some personal interest in this topic.

PE The student demonstrates some curiosity here.

I finalized my investigation to deal with the rebound height of different size soccer balls when they rebound off of different materials with different pressures, and that I should test the rebound height of the ball when it is under inflated and over inflated.

EX The student addresses too many variables. The pressure and COR alone would have been interesting. The teacher should have guided the student to focus this way or another.

After some research I discovered that the ideal pressure for a size 5 soccer ball is 6-8 Lbs. FIFA measures the pressure of the ball in bars but for this experiment I will use lbs. In physics we usually talk about air pressure in atmospheres, but for soccer balls the pressure is usually measured in Lbs. or bar.

Coefficient of Restitution

The coefficient of restitution is a mathematical way of showing the elasticity of a collision. It can be used when two moving objects collide or when a moving object hits a stationary object. In my investigation a moving object (a soccer ball) will collide with the ground. There are many formulas to calculate the coefficient of restitution depending on the data that you are given, but the one listed below specifically deals with the height of ball bounces.

EX The basic scientific context is given here.

$$C_R = \sqrt{\frac{\text{Rebound Height}}{\text{Initial Height}}}$$

If the collision is perfectly elastic, meaning that no energy is transferred, the coefficient of restitution will be 1. Collisions are not perfectly elastic because energy is lost on collision. If the coefficient of restitution is 0, the collision is completely inelastic and all energy is transferred from the ball to the ground, friction, sound, heat and other forms of energy loss. This would mean that when the ball drops, it doesn't bounce back.

Energy Transfer in this experiment

C Somewhat wordy here; could have been more precise.

The soccer ball is first raised up to a specific height. In this action energy is being transferred from the person to the ball. When the ball is resting at its maximum height all of its energy is gravitational potential. As the ball is released, gravity accelerates it towards the

ground. As it is accelerating, the energy is transferred from potential energy to kinetic energy. The instant it hits the ground all of the energy is kinetic energy but it is quickly transferred to elastic potential energy when the ball deforms. The elastic potential energy is then transferred to kinetic energy again when the ball rebounds back up. This kinetic energy is then transferred to gravitational potential energy. At any part in the path of the ball, the energy is a combination of kinetic and potential.

When the ball rebounds back up it will not reach its original height due to energy loss. The energy loss occurs when the ball hits the ground. Energy is loss to sound and heat. When the ball loses energy it is not able to reach its maximum height.

Research Questions: What are the optimal conditions for a bouncing soccer ball to achieve the maximum rebound height?

EX As a research question(s) it is not concise. Moreover, the student is dealing with too many variables.

Independent Variable: In this experiment I will be testing the impact of three different variables on the rebound height of the ball. The most important variable that I will be changing is the pressure of the soccer ball. In order to enhance this experiment I will change the surface that the ball bounces on. The three surfaces that I will be using are grass, stone and dirt. I will also be investigating if the size of the ball affects the rebound height. I will be using size 1, size 3 and size 5 soccer balls.

Dependent Variable: The dependent variable in this experiment will be the rebound height of the soccer ball.

Control Variable: In this experiment there are many control variables that will be put in place to ensure our results are as accurate as possible. Control variables are used to ensure that only one variable is being changed in each experiment. Since this investigation deals with three independent variables, only one will be changing at a time. Here is a list of the control variables:

EX The student is aware of the importance of the other variables.

Height that the ball is dropped: The ball will always be dropped from 150cm above the test surface.

Surface that the ball is being dropped on: When I change the pressure of the ball the surface will remain the same for all trials.

Soccer ball: The size 5 soccer ball that is used will always be the same for every trial. The same goes for the size 1 and size 3 soccer balls.

Materials: Laptop, Vernier LabPro interface, Motion sensor, Meter stick, Air pressure gauge (measured in Lbs.), Air pump, Size 1 soccer ball, Size 3 soccer ball, Size 5 soccer ball, Grass area, Dirt area, Limestone Area, Pole (at least 1.5 meters high), Chair/table to help hold apparatus during data collection.

Procedure

1. Stick a pole into the dirt surface where you will be doing the first experiment.
2. Put tape on the stick 150cm above the ground.
3. Set up the motion sensor and Vernier to your laptop.
4. Using chairs/ tables place the motion sensor approximately 175cm above the ground. Make sure it is set up beside the pole. (I had to move my pole to make it work with the motion sensor.)
5. Inflate size 5 soccer ball to 12 Lbs.
6. Hold up the ball so the middle is at the tape (150cm).
7. Start collecting data with LabPro
8. Drop ball.
9. Stop data collection when ball has bounced and returned to the ground
10. Save data.
11. Complete 3-5 trials for each ball, pressure and surface.
12. Once all trials are completed, analyze data and record in data tables.

EX The method is appropriate once we focus the question and the student is aware of basic scientific practices.

Safety/Setup Considerations:

- Ensure the motion sensor is securely placed on the table. Use tape to keep it down if necessary.
- Place your laptop as far from the bouncing ball as possible to ensure it does not get hit by the rebounding ball.

EX Safety issues are addressed. There are no environmental or ethical issues here.