Proper Inflation of a Basketball

by

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Abstract

This paper describes an experiment to determine how to correctly inflate a basketball using a hand pump. A basketball is correctly inflated when it rebounds to approximately 60% of the height from which it is dropped. In this experiment, the basketball's rebound height is measured as a function of the number of strokes of the pump used to inflate it. We find that for the pump used in this experiment, 12 strokes gives the correct pressure in the basketball. We discuss the effects that the air temperature and the material from which the ball is made have on the accuracy of our results.

Introduction

Basketball is a game that relies on the skill of dribbling—that is, walking or running while bouncing the basketball on the floor. To play the game most effectively, players need to be able to rely on the rebounding of the ball off the floor as they move with it around the court. The "springiness" of the ball also affects shots that rebound off the backboard. The amount that the ball rebounds depends on how much air is used to inflate it. A ball with too little air is flat and difficult to dribble. A ball with too much air is too lively and more difficult to control when dribbling and shooting. Inflating a basketball with the correct amount of air is important to being able to play the game well.

According to international basketball rules, a basketball is properly inflated "such that when it is dropped onto the playing surface from a height of about 1.80 m measured from the bottom of the ball, it will rebound to a height, measured to the top of the ball, of not less than about 1.2 m nor more than about 1.4 m" (Fédération Internationale de Basketball 1998). Accounting for the 24-cm diameter of the ball, this means that a properly inflated ball rebounds to 62 ± 6% of the height from which it is dropped. Unfortunately, using this standard alone to determine when a ball is properly inflated implies a significant amount of trial and error—pump some air into the ball, remove the pump, drop the ball and test its rebounding, pump more air into the ball, and so forth. In this experiment, we develop a method to determine the correct number of strokes of a specific hand pump needed to correctly inflate a basketball.

Materials and Methods

The basic setup for this experiment is shown in Figure 1. We used a wooden 2-meter stick to set a uniform height, $h_0 = 1.8$ m, from which we dropped a basketball and to measure the height h of its rebound. As shown in Figure 1, h_0 was measured from the floor to the bottom of the ball, while h was measured from the floor to the top of the ball, in accordance with international rules (Fédération Internationale de Basketball 1998). We used a video camera to record the motion of the basketball. By examining the video recording frame-by-frame, we could capture the ball at the top of its rebound.

The video camera we used was an 8-mm format (Sony model CCD-F301). The resolution of the image in the "stop-action" frame was the critical factor in determining the precision of our height measurements. In order for the marks on the meter stick to be seen in the frame, we darkened every centimeter marking with a permanent marker. The precision of our individual height measurements was ± 1 cm.

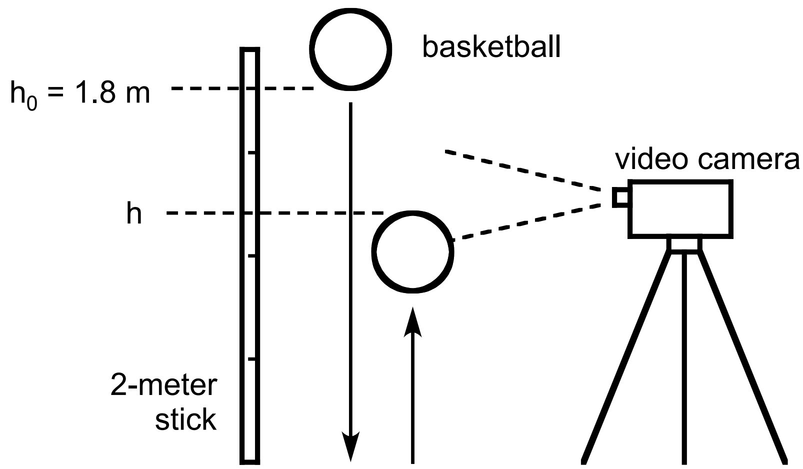

Figure 1. To determine the rebound height of a basketball, a video camera was used to record its motion with a meter stick in the background.

The basketball we used (Wilson "Zone Buster" model P1350) was made of molded rubber. We measured the diameter of the ball by holding it flush to the wall with a book (a convenient right angle) and then measuring the distance from the edge of the book to the wall. The ball had a diameter D = 24 cm, as shown in Figure 2. We estimated that the wall thickness of the ball was 0.25 cm. We therefore considered the wall thickness to be negligible compared to the diameter of the ball. Before beginning the experiment, we inserted an inflating needle into the basketball to equalize its internal pressure with that of the surrounding air.

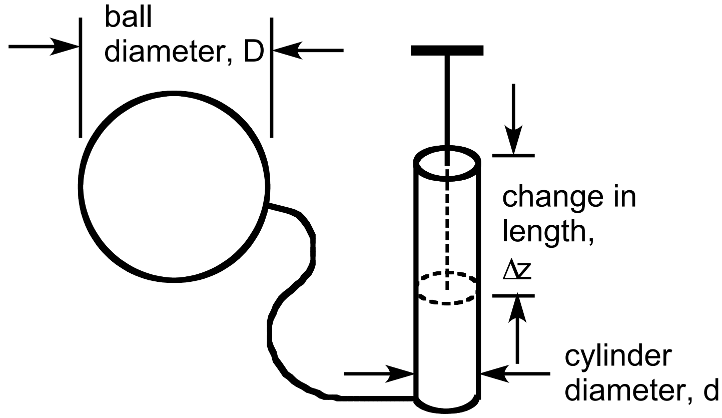

Figure 2. The outside diameter of the basketball we used was D *= 24 cm. The inside diameter of the pump cylinder was* d *= 3.4 cm and the length of its stroke was* Δz *= 38 cm.*

The pump we used to inflate the basketball was a common hand pump. We disassembled the pump to measure the inside diameter of the cylinder, d = 3.4 cm, and reassembled it to measure the length of its stroke, Δz = 38 cm. These measurements allowed us to determine the volume of air that was pumped into the ball with each stroke of the pump. We conducted our experiment inside, using the thermometer of the room's thermostat to measure the temperature of the surrounding air, T = 70 °F (equivalent to 21 °C). We dropped the ball onto a hardwood floor.

To complete the experiment, we inflated the basketball, counting the number of strokes N that we used. We then dropped the ball from a 1.8-m height and recorded its rebound height h. We repeated this measurement five times. We then inflated the ball some more, counting the additional number of strokes ΔN that we used, and repeated our measurements of the ball's rebounding with this new total number of strokes N. We repeated this process until the ball rebounded to over 62% of its initial height.

Data and Analysis

The specific results from this experiment allow us to determine the proper number of strokes of our hand pump needed to properly inflate the basketball.

Experimental Results

Some typical data describing the rebounding of the basketball are shown in Table 1. From these data we can see that there is a small amount of variation in the rebound height from one trial to another, even for identical conditions. This is most probably due to variations in the initial height from which we dropped the ball. For each set of trials, we took the average of the individual rebound heights to represent the rebounding of the ball at that amount of inflation. We took the standard deviation of the five trials to be the uncertainty in each of these averages.

Figure 3 shows the variation of rebound height h as a function of the number of strokes of the pump used to inflate the basketball. We drew a smooth curve through these points. From these data, we see that the proper number of strokes to inflate the basketball is $N = 12$.

Table 1. Typical data describing the rebounding of the basketball. These data were taken for the case of 15 strokes having been used to inflate the ball.

rebound height h [m]					average h [m]	uncertainty σ_h [m]
trial 1	trial 2	trial 3	trial 4	trial 5		
1.31	1.34	1.34	1.34	1.36	1.34	0.02

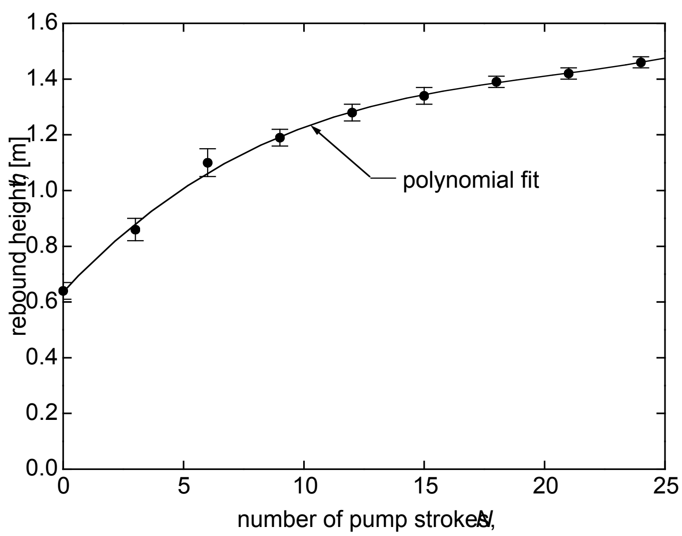

Figure 3. Rebound height h *as a function of the number of strokes of the pump used to inflate the basketball.*

Discussion

These results were obtained at a fixed temperature. We know from experience that as the temperature increases, the pressure in the basketball will go up. Conversely, as the temperature goes down, the pressure will decrease. We observed this firsthand: when we brought the ball in from the cold garage, it was noticeably flat. This is the largest source of uncertainty in this experiment. Our results are not valid for different temperatures.

We neglected the effect of the material of the ball on its rebounding when doing this experiment. The material of the ball has some elasticity to it, and a leather basketball would bounce slightly differently than a rubber one. Our results show that this is a more important effect when there is very little air in the ball (see Figure 3). Even a little air dramatically changes the ball's rebounding, as shown by the initially large slope in the best-fit line. The experiment could be improved by repeating it with other basketballs of different materials to verify this assertion.

Conclusions

We have determined the optimum number of strokes of a hand pump needed to properly inflate a basketball. We have found that 12 strokes of our pump inflates our basketball so that it rebounds to within 62 ± 6% of its original height when dropped. Inflating the ball raises the pressure of the air inside it and gives it additional elasticity. Our results are valid for a temperature of 70 °F. Extending our results to other temperatures would require additional analysis, measurement, or both. Repeating these tests with basketballs made of other materials would confirm our assertion that the material of the ball has little effect on its rebounding once it is fully inflated.

References

Fédération Internationale de Basketball. *Official Basketball Rules.* URL: http://www.worldsport.com/worldsport/sports/basketball/rules/rules2.html, December 29, 1998.

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