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The vibrations in a rubber baseball bat

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"*It might be . . . it could be . . . it IS! A home run! Holy cow!*"[1] The collision between the ball and the bat is far more complex than the collision of idealized point particles we emphasize in introductory physics. Yet, the key factor in hitting a homer is simply maximizing the kinetic energy in the ball. So, the trick is to minimize the amount of energy lost to other forms.

One of the ways energy is lost to the ball is in the vibrations of the bat. The common way to investigate these vibrations is to listen to them.[2] Some ball players are aware of the importance of vibrations in the bat and actually claim to be able to tell a good bat from a bad one by listening.[3]

Bat vibrations can actually be seen during the broadcast of Major League games when they use super slow motion cameras. Unfortunately, the author can't get permission to use these MLB images here. However, a wonderful episode of "Time Warp"[4] illustrates bat vibrations in a lab environment.

You and your students can actually see and study these vibrations by using a rubber baseball bat,[5] shown in Fig. 1. Below are a couple of suggested activities that you'll enjoy.

Activity 1: Traveling Waves

Hold the bat by the handle and let it hang down. Strike the bat with a mallet (or make a "baseball hammer") at different locations along the bat. You might notice that near the handle, you create a pulse that travels along the bat as shown in Fig. 2. As you work your way down, you find a spot where there is little or even no pulse created. This is sometimes referred to as the "sweet spot"[6] for two reasons. Since there are few vibrations, there is more energy available for kinetic energy in the ball. Additionally, it feels great to batters because they don't get any vibrations back at their hands. As you continue down toward the barrel end of the bat, the pulses again start to appear.

Activity 2: Standing Waves

You can examine the standing waves in the bat by holding it from the barrel end. Shake it back and forth until you find the frequency for the standing waves. I can usually find the first (see Fig. 3) and second normal modes. Note the words "normal modes" as opposed to "harmonics." These normal modes are not simple multiples of a fundamental frequency, so they are not harmonic.[7] Also, understand that you are

Fig. 1. The rubber bat and a baseball hammer.

Fig. 2. A pulse created by a collision with the baseball hammer.

Fig. 3. The first normal mode or standing wave in the bat.

looking at the normal modes of the bat held at one end, while in a real ball-bat collision, the batter is not nearly strong enough to keep his end of the bat from vibrating. Therefore, the "sweet spot" you found in the first activity may not precisely match the nodes you find in this one.

References

1. Harry Carey's famous standard home run call.
2. For example, see Paul Doherty's activity at www.exo.net/~pauld/activities/baseball/batnode.htm.
3. "The Mets' Bat Whisperer," *The New York Times*, June 12, 2011. Available online at www.nytimes.com/2011/06/12/sports/baseball/sweet-music-to-beltrans-ears.html.
4. Available on YouTube at www.youtube.com/watch?v=QFlEIybC7rU.
5. The bat was specially made for me by Specter Studios (www.specter-studios.com/) and cost $55 including shipping. I had to explain several times that I really did not want the dowel in the middle of the bat.
6. The "sweet spot" is actually an ill-defined term. A wonderful discussion of the issue can be found at www.kettering.edu/physics/drussell/bats-new/sweetspot.html.
7. W. C. Elmore and M. A. Heald, *Physics of Waves*, 1st ed. (Dover, New York, 1969), pp. 114-122.