Chapter 14
The Sweet Spot of a Bat

Some of the longest home runs I’ve hit, I didn’t actually realize they were going that far. Everyone says, What does it feel like to hit the ball that far? Actually, there’s no feeling at all. I know when the ball meets the bat whether or not it’s left the park. It’s a nice easy thing.

– Mark McGwire

14.1 Introduction

An interesting aspect of a bat and ball collision, from both a practical and a physics point of view, is that the batter can exert a huge force on the ball without feeling any particular discomfort at the handle end of the bat. The force on the ball is much larger than the force exerted by the batter on the bat. The batter swings the bat by exerting a force of around 50 lb on the handle. The bat then magnifies that force by a factor of about 100 to 5,000 lb or so when it collides with the ball, enough to squash the ball almost in half. Only a small fraction of that huge force gets back to the handle to trouble the batter. If the ball is struck at the sweet spot of the bat, then the batter feels almost no effect at all. It seems almost as if Newton’s third law does not apply to baseball or softball bats. Newton’s third law says that for every action there is an equal and opposite reaction. If there is a force of 5,000 lb on the ball then there will definitely be a force of 5,000 lb acting back on the bat. How come the batter is blissfully unaware of that fact?

Newton’s third law is not violated when a batter swings a bat, nor when the bat strikes a ball. The subtlety here is that there are two separate pairs of forces acting on the bat. There is an equal and opposite force between the bat and the ball, acting at the barrel end, and a different equal and opposite force between the bat and the batter’s hands, acting at the handle end. Fortunately for the batter, the force at the handle end is a lot smaller than the force at the barrel end. In this respect, a bat acts in the same manner as a hammer. You can hammer a nail using a small force on the handle to generate a much larger force on the nail. You only notice the large force at the heavy end of the hammer if you accidentally hit your thumb instead of the nail.

The different forces acting on the bat and the batter can be explained by a simple analogy. Suppose you punch a brick wall with your bare fist as hard as you can. The brick wall will probably survive intact and you will probably injure your hand. In that case, the effect on your fist is not exactly the same as the effect on the brick wall. Newton’s third law has nothing to do with the consequences of the actions and reactions. The law is concerned only with the equal and opposite forces. The force
of the brick wall on your fist is equal to the force of your fist on the wall, but it acts in
the opposite direction. If you hit the wall, the wall will hit you back with the same
force. The wall doesn’t stop to think about it. It doesn’t give you a chance to run
away before it hits you back. It reacts instantly. That force, acting on weak bones,
can break those bones. The same force, acting on a strong brick, is not enough to
break the brick. In the process, while injuring one hand, you will feel nothing in
your other hand or your feet. The force and the reaction force are both exerted at the
point of impact. If you kick the wall you won’t injure your fist. You will injure your
foot. It is the same with a bat and a ball.

When a bat collides with a ball, the force of the ball on the bat does not act on the
handle, nor does it act on the batter’s hands. It acts on the bat at the point of impact
on the barrel. The barrel is a lot heavier than the ball, with the result that the barrel
will slow down a fraction but it will continue moving in the same direction as before
the collision. It is like a heavy truck slamming into a basketball. The truck will slow
down a fraction, but it won’t come to a stop or reverse direction. It’s the same with
the barrel of a bat. The question is, what happens to the handle of the bat when the
barrel slows down a fraction? If we can answer that question then we can figure out
the force that is exerted by the handle on the batter’s hands.

The situation is shown in Fig. 14.1. Before the bat strikes the ball, there is es-
sentially zero force on the ball, although the air does slow it down a fraction as it
approaches the bat. The only force on the bat is the force exerted by the batter on the
handle, around 50 lb. The handle exerts an equal and opposite force on the hands.
That 50-lb force doesn’t bother the batter, but it does slow down his swing speed a
fraction, particularly if he is using a heavy bat. He could swing his arms a fraction
faster if he didn’t have a bat in his hands.

On impact, the force on the ball increases rapidly as the ball squashes, up to
about 5,000 lb. That force brings the ball to a complete stop before it turns around

![Fig. 14.1](image)

Fig. 14.1  (a) The batter exerts a force of about 50 lb on the bat in order to swing it. (b) The bat
exerts a force of about 5,000 lb on the ball, and the ball exerts an equal and opposite force on the bat