The Physics Of Forces In Aikido: Making The Weak Equal To The Strong

By Jearl Walker

Like Judo, Aikido is a martial art that demands an intuitive understanding of the physics of forces, torques, stability and rotational motion. This article examines a few of the basic aikido techniques. The grace that each requires is not easily conveyed, but each technique can be broken into components that can be examined in terms of classical physics. The experiments I shall describe call for actual performance of the technique, but you should do them only under expert supervision since aikido if performed incorrectly can be dangerous to you and your opponent.

Aikido is similar to judo in that it seeks to overcome the opponent's stability. Aikido, however, is a relatively modern form of martial art that incorporates techniques from a number of other martial arts. It is distinguished by its firm code of avoiding injury to the opponent. Hence it is a form of self-defense rather than a sport like judo. It involves no techniques that can be regarded as attacks. I think it is the most difficult of all the martial arts to learn. Its demands for skill, grace and timing rival those of classical ballet.

Aikido employs many of the same principles of physics that are found in Judo. Suppose your opponent grasps you by the wrists from behind. In one aikido maneuver you smoothly lower your body while bringing your wrists upward and over your head toward the front.

Your opponent hangs on to your wrists but is brought forward by your descent and slight lean forward. His position is therefore unstable because his center of mass is now slightly forward of his feet.

You draw your right leg backward and drop onto your right knee. Your arms and torso are brought forward and downward in a large arc. Because the first part of the motion induced your opponent to hold tightly to your wrists, he is now thrown over your body in a front somersault.

As in much of aikido, your opponent actually throws himself. He cannot prevent your forward motion because of the unstable posture in which you initially place him. Even if he has superior body weight, he cannot stop the motion by pulling downward on your raised wrists. In such a position he can pull only along the length of your arms. The torque due to such a pull is zero because there is no "lever" (described in Part I in this series, "The Physics Of Forces In Judo: Making The Weak Equal To The Strong").
Remember, the lever is the perpendicular from the pivot point (in this case your shoulder) to the line through the force. The line through the opponent's pull passes through your shoulder and therefore has no lever arm. Even if he is heavy or strong, he cannot rotate your arms once you have them properly over your head.

Many of the techniques in aikido employ the deflection of a force directed at you. Suppose your attacker throws a punch at your face. To stop the punch directly requires a large impact force which could cause injury. A wiser technique is to deflect the strike. Although a large force is necessary to stop the punch directly, only a small force is needed to deflect it.

Although most followers of Western style fighting consider an attack to be an advantage, in aikido the attacker is at a distinct disadvantage because of the momentum of this strike. You can use his momentum to throw him to the mat.

Suppose the attacker steps forward with his right foot and slashes at your face with the side of his right hand (a typical attack in Western styles of fighting and in karate). You slide your left foot to the rear as you parry his slash with your left arm. The parry is meant to deflect the slash, not to stop it or even to slow it, since either effect would require strength from you. During the parry you guide your attacker's right arm downward into the grasp of your right hand. While still not fighting the forward momentum of his slash, you pull him around in the circular motion you have begun with the withdrawal of your left foot.

The opponent was relatively stable against a pull directly forward because of his extended right foot, but is highly unstable against a pull forward and to his left. In such a direction his center of mass does not have to be moved far before he becomes unstable against a fall. Therefore as you continue to circle you pull him in that direction. He now has two serious disadvantages. First, he is committed to a forward motion that would take a considerable force to stop, even from himself. Second, your pull and his motion are removing his center of mass from his base of support.

To complete the throw rotate your attacker's right arm downward while stepping to your left rear. Turn his wrist upside down and bend his hand around it. At this point it is impossible for him to prevent the throw. He is now off balance and completely unable to stop his own motion. He also cannot pull out of your grip because you have bent his arm at the wrist. Although his arms may be strong, he cannot prevent the torque you create when you push his hand around his own wrist. You bring him to the mat.

How would a strike to the head be handled in karate? In the Korean style of karate known as "tae kwon do," I was taught to parry a slash with a powerful strike across the opponent's arm. Deflection was important but so was countering the slash with a large force. Force was working against force, and usually the stronger person won (I was rarely that person).

In contrast, circular motion is employed in aikido both for deflection and to aid in throwing an opponent off balance. Suppose someone approaches you from behind, reaches around your body and pins your arms to your sides. You should reach upward and hold his hands tightly to your chest while sliding your foot forward.

The timing is critical because you want to move your torso forward at a rate matching the speed of your opponent. If you delay, you will lose the advantage of exploiting his momentum. If you move too fast, you will have to drag him forward. You must slide your right foot forward at the correct speed and then suddenly lean forward and rotate your body to the right.

The combination of your opponent's momentum and your rapid rotation throws him off balance to the right. He cannot prevent your throw because your lean forward brings his center of mass forward of his feet. He cannot release himself from the forward motion because of his established momentum, because you have pinned his hands and because of his grip around your arms. The centrifugal force on him during your rapid rotation is too large for him to deal with in this unstable position. Hence he essentially throws himself to the floor.

Two more examples of how aikido employs a small force to bring an attacker off balance entail stick fighting (called a jo) that is taught to more advanced students. Suppose an attacker thrusts a long stick at your midsection, advancing with his left leg during the lunge and thrusting the stick horizontally, holding it with the palms of both hands down. It would be futile to try to stop the end of the stick. You rapidly step forward with your right foot so that the stick passes you on your left. (The agility to do this comes only with long practice.) As the stick passes you, turn your body to face it so that you can grab it with both hands. Your left hand is forward of your attacker's outermost hand. Your right hand is between his hands.

In grabbing the stick your objective is not to stop its motion, which would require considerable force. Rather it is to deflect the lunge upward, around to your left in a circular motion and then up and over your attacker's head. Once he has committed himself to the forward lunge he can do little to prevent the deflection. He would need a large force to stop his momentum, and he cannot thrust horizontally at your midsection while pulling downward to prevent your deflection.

Once you have the stick over your attacker's head he is easily thrown. With his left foot forward he is highly unstable against a pull to his left rear because in that direction his center of mass must move only a short distance before it is no longer over his support area. When you have the stick over his head, you pull it downward over his back in that direction. He falls to the mat on his back and probably releases the stick.

Suppose you have a stick and a determined attacker rushes forward to grab its forward end. Allow him to grasp it, but lead him with it (as if it were a carrot in front of a donkey) so that he continues his rush. Also lower your end of the stick (the end he is grabbing) to trick him into bending downward.

Once he has committed himself to this awkward motion and is about to pass to your right side you bring your end of the stick upward over his face and then back downward over his back. If this motion is executed rapidly, he still has a strong grip on the stick and therefore is bent backward by

your pull downward over his back and by the continued forward motion of his torso. The torque due to his own weight rotates him to the floor around the pivot point of his feet. His grip on the stick also provides a torque that rotates him. He actually throws himself to the mat because of his initial forward thrust and a bit of trickery on your part.

Aikido has hundreds of techniques for employing such trickery against a determined opponent. In nearly all of them a small deflection of force parries an opponent's thrust and then guides it so that he throws himself down. When I watch an aikido master defend himself, the motion seems fluid and effortless, and I am inclined to suspect the opponent of faking when he falls to the floor. The fall is not faked. It looks that way because the master has spent years developing an intuitive feeling for the basic physics of forces, rotation and torques.