Get a Kick out of Physics

By: David P. Hildreth and Catherine Matthews

Hildreth, D., & Matthews, C. (1997). Get a Kick out of Physics: Using the art of Tae Kwon Do to interest students in Physics. *The Science Teacher*, *64* (9), 34 - 36.

Tae Kwon Do, the Korean martial art, literally translates to mean the way of the hand and foot. Educators can use some of the hyungs (forms and patterns) of this martial art to explain to students a fundamental and integral physics equation —f = ma (force = mass x acceleration)—in an interesting and exciting way.

What separates Tae Kwon Do from karate and other martial arts is that kicks are 90 percent of the moves and techniques of Tae Kwon Do. In addition, these kicks are usually thrown very high and with extreme force, hence the notion that Tae Kwon Do is a "hard" martial art. When kicks or punches are thrown in other martial arts, they are usually not thrown as high or with as much force. Some of these disciplines may be considered "soft" because they do not rely on such extreme force in their techniques.

To give students background and to spark their interest, we explain to them that rankings in Tae Kwon Do are signified by belts. In general, black is the highest ranking belt (with ninth degree being the highest degree obtainable) and white is the introductory or lowest level belt. In order to achieve advanced belts at many Tae Kwon Do schools, students must demonstrate an ability to break boards with various kicks or punches. This is not to show one's strength but rather to demonstrate the ability to use proper techniques, which is a crucial goal in the martial arts. In Tae Kwon Do, technique is defined as the ability to perform a move, kick, or punch properly and efficiently. When a kick or punch is executed skillfully, an individual can produce an extreme amount of force quite easily.

CLASSROOM APPLICATION

To use Tae Kwon Do to depict the basic principles of the equation f = ma, teachers can use pine boards that are 29 cm x 29 cm x 2 cm, which are easily obtained and cut at a local hardware store or lumbar yard. A simple way to convey the idea of force is to use different weights (masses), which can be borrowed from a physical education instructor, to break the boards.

According to Zitzewitz and Murphy (1990), objects of different masses (the weights used in this demonstration represent masses) can be dropped from various heights and, as long as the air resistance is ignored, the acceleration will be the same. On Earth, a freely falling body has a downward acceleration of 9.80 m/s^2. For example, a 1.4-kilogram weight dropped from 1 meter above a board that is supported between two bricks on each side will have a force of 1.4 kg x 9.8 m/s^2 = 13.72 kg x m/s^2 or 13.72 Newtons. Units of force are represented by Newtons: kg x m/s^2. Theoretically, the heavier the weight (mass), the larger the force, and so the heavier the weight dropped on the board, the more easily the board will break. Teachers can either demonstrate breaking the boards with the weights or let teams of students do the experiments themselves. Figure 1 shows the results recorded by our class while doing this experiment. Teachers may want to consider the following safety guidelines when planning this activity:

- When placing the boards on the bricks, 3 centimeters should be left on each side of the board.
- The class should work outside on the grass to avoid damaging the floor. We also recommend placing pads, sleeping bags, wrestling mats, or old clothes around and under the bricks as cushions.

- Care should be used when the weights are dropped in case the boards move as they break. Students should stand away from the boards.

It is important that students realize that results will vary from experiment to experiment due to factors such as the type of boards used and the striking point of the weight. Board quality often differs, so we purchase wood with few knots and cracks. In addition, the location on the board where the weight lands can affect whether or not the board will break. We get the best results by aiming for the middle of the board. This is a good opportunity for teachers to discuss the importance of controlling and manipulating variables and the steps associated with conducting careful science experiments.

IN-CLASS DEMONSTRATION

To augment these experiments, teachers can invite local Tae Kwon Do instructors to come to the classroom and demonstrate the way they use force to break boards. When we schedule such a lesson, we meet with the martial artist(s) and explain the purpose of the demonstration and the scientific concepts that will be emphasized. The Tae Kwon Do practitioners can then demonstrate force in several ways. For example, they can show increased force by successively breaking one, two, and then three boards with either a kick or a punch.

It should be intuitive to the students that an increased force is needed to break the boards as the boards increase in number, which increases the boards, resistance to being broken. At this point, the classroom teacher should describe how the Tae Kwon Do instructor uses increased acceleration to get an increased force while the mass (the instructor's hand or foot) remains constant. An increase in acceleration in the instructor's strike is needed to provide the necessary force to break the additional boards. This teaches students that acceleration is directly proportional to force as illustrated by the equation $a = f/m$, which implies that, in order to increase the force of an object, the acceleration must also increase.

This concept is also illustrated in the experiments with the weights. For example, a light weight has less mass than a heavy weight and will produce less force than the large weight when acceleration is constant. Likewise, a Tae Kwon Do practitioner who has more muscle mass and strength will have the ability to generate more striking force than a practitioner with less muscle mass and strength. Thus, in order for the smaller practitioner to generate a force comparable to that of the

FIGURE 1.

The results of an experiment that manipulates the variables in the equation $f = ma$.

Trial	Weight used	Distance	Effect on board
I	1.4 kg	1 meters	unbroken
II	1.4 kg	2 meters	unbroken
III	2.8 kg	1 meter	broken
IV	3.6 kg	1 meter	broken
V	3.6 kg	0.5 meter	unbroken

stronger practitioner, he or she will have to strike the board faster; that is, the smaller practitioner will need to strike the boards with more acceleration in order to generate the force needed to break the boards. It should be clear to students that the mass of the object (the instructor's hand or foot) does not change, so the acceleration must change in order to generate the requisite extra force needed to break the additional boards.

Using Tae Kwon Do, students and teachers get a kick out of learning physics. Many other subjects could also be incorporated into the study of physics, and the more creative teachers are with their lessons, the more likely students are to remember the concepts.

REFERENCES

Zitzewitz, P. W. and J. T. Murphy. 1990. *Physics: Principles and Problems*. Columbus: Merrill Publishing Company.