Physics Behind the Martial Arts
Part Four
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Topics

Physics Analysis of Martial Arts: Board Breaking

Note: I would recommend that the physics articles be read in order listed as I define terms in earlier physics articles that are assumed in the later physics articles.

Introduction

Martial Arts can be thought of as applied physics to the body for defense or offense against an opponent. In Martial Arts you are applying forces against an opponent and leverage against the body structure. In defense, you would be blocking or immobilizing an opponent. In offense, you would striking or applying joint locks to an opponent. Of course there is overlap, like the old saying that "a good offense is a good defense."

Physics is the branch of science concerned with the nature and properties of matter and energy. The subject matter of physics, distinguished from that of chemistry and biology, includes mechanics, heat, light and other radiation, sound, electricity, magnetism, and the structure of atoms. For Martial Arts, we will be looking at the mechanical part of physics.

In these physics articles, I have tried to explain some of the basic concepts of physics, including a definition of a physics concept and an everyday example. Hopefully I also related the physics concept to some Martial Arts examples and applications.

I hope you won't get uptight with the word “physics.” You do not have to follow each concept in detail, unless you wish. You do not have to understand it all. You do not have to read every word at one sitting. Take a quick look. Look at just one concept. Look at the everyday examples. Look at the results of calculations and numbers, not the calculations themselves. Think about how the martial art examples are similar to the everyday examples. This will still allow you to get a feel of the overall concepts. Hopefully, an understanding of the basic concepts of physics will give you a more in-depth understanding of, and how to better apply, your martial art training.

Happy reading.

Physics Analysis of Martial Arts: Board Breaking

For completeness, and for those who enjoy seeing every step, I have including the math here with the physics equations. You do not have to follow each step in detail, unless you wish. Looking only at the results will still allow you to get the overall concepts.

A well-executed karate strike delivers to its target several kilowatts (thousands of watts) of power over several milliseconds (one thousands of a second), quite enough to break blocks of wood and concrete. For a linear punch, the hand of the practitioner of karate can develop a peak velocity of 6 m/s to 10 m/s ((18.7 ft/s and 32.15 ft/s)) and has a mass of 0.65% (0.56%) of the male (female) body mass. For a faster strike, the overhand strike, the hand can have a speed of 10 m/s to 14 m/s.

For a 70 kg (155 lb.) male, the hand would have a mass of 0.46 kg and the forearm would have 1.14 kg of mass.

For the hand alone, at 10 m/s, the

$$KE = 0.5 \bullet m \bullet v \bullet v$$
$$KE = 0.5 \bullet 0.46 \text{ kg} \bullet 10 \text{ m/s} \bullet 10 \text{ m/s}$$
$$KE = 23 \text{ Joules.}$$

And at a speed of 14 m/s, the hand would deliver 45 Joules of energy.

The force needed to break the ribs of a person corresponds to the energy needed to break a one inch thick pine board one foot by one foot square. The energy needed is about 30 Joules. It would seem that an overhand strike can break the board, but that a linear punch can not.

The average forearm has a mass of 1.63% (1.38%) of the male (female) body mass. Using proper bone alignment of fist and forearm, a part of the mass of the foreman can be considered added to the fist. This enables more energy to be delivered in the linear punch. (This analysis is much more difficult for the hammer strike, since the fist is moving in an arc, the forearm is not moving as fast as the end point of the arc, the fist. Also the forearm is not in line behind the fist when it hits.)

For our 70 kg male, At 10m/s, the energy from the forearm alone will be 57 Joules, adding this value to the fist and we get a total of 80 Joules of energy.

Since the total mass of the forearm may not contribute, the total energy will be less, say about 40 or 50 Joules. However, this is well over the 30 Joules needed to break the board.

Note: This information should only be used to increase your knowledge of the martial arts. It is not meant to be used without the supervision of a qualified instructor.

It should be noted that the energy needed to break the hand is considerably more than that needed to break the pine board (or a rib). Therefore, when done with proper technique, we do not need to worry about the hand. However, I have seen cases where improper technique such as wrong bone alignment can cause a sprained or broken wrist.

Another thing that can happen is that the person, trying to break the board gets cold feet and does not follow through with the punch allowing the board to stop the hand, without breaking the board. This will deliver a large change in momentum to the hand, the hand going from high speed to zero in a fraction of a second. I have seen this case a number of times. If the person is going slow enough, it will only hurt or bruise, but it can and has resulted in a broken knuckle.

Newton's 3rd Law says that if you exert a force on the board by your hand, then the reaction to that would be the force the board exerts on the hand.

We can use the concept of Impulse to calculate the force on the hand by the board.

Force • time interval = mass • change in velocity

Solving for the force we get

Force = (mass • change in velocity) / time interval

Assume the mass of the fist for a male of 70 kg, and the change in speed to be from 10 m/s to 9.8 m/s, and the time interval to be one hundredth of a second.

Force = (0.46 kg) (0.2 m/s) / 0.01 s
Force = 9.2 Newtons

This value of force is not enough to cause damage to the hand.

However, if the board does not break, then the change in speed will be from 10 m/s to zero.

Then
Force = (0.46 kg) (10 m/s) / 0.01 s
Force = 460 Newtons

This is a factor of 50 times, a tremendous increase.

Even if these numbers are not completely accurate for a given case, they show relative results that should be in the ballpark.