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Knockout Science

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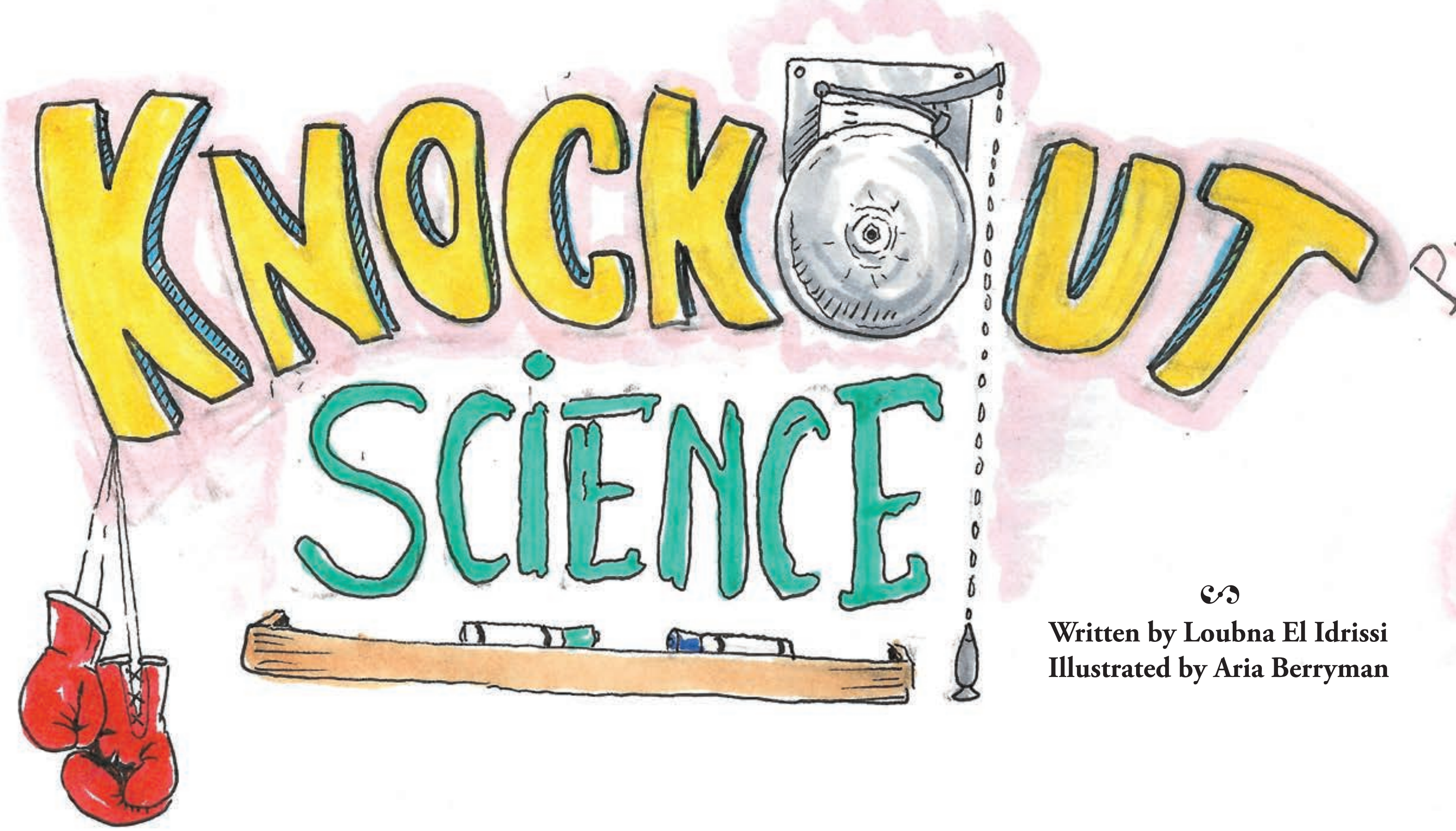

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Illustrated by Aria Berryman

As a first year, I am frequently asked about my academic interest. Most of the time, when I express my enthusiasm in pursuing a physics major, I notice that people are often fascinated by the subject, yet scared of its difficulty. During my 2018 Winter Term project, I brought the abstract concepts of my Physics 110 class to life with the help of something less complex: sports. Since this helped me better understand those concepts, maybe it can help others as well. Inspired by the Housemate Questions from the infamous Wednesday problem set, this article intends to make physics more accessible by explaining some of the laws and concepts that I learned during the fall 2017 semester and applying them to boxing.

Basic physics is just as intuitive as boxing. During this Winter Term, I wanted to work on my boxing moves and technique to become more efficient. In other words, I wanted to punch harder. Some think that giving good punches is about developing more force and power. In everyday life, force and power are interchangeable words. However, in both physics and boxing, they have distinct meanings. Strength or force is a component of power. To make a punch efficient, you have to be both fast and strong; that's power. Power, as explained by my kickboxing coach, is the ability to develop a maximum force as quickly as possible. The scientific definition of power is the rate at which work is done, or the rate at which energy is transferred from one place to another, or transformed from one type to another. Work is done when a force that is applied to an object moves that object:

$$P = \frac{Work}{time} = force.\frac{displacement}{time} = force.velocity$$

A fast punch will not hit hard unless there is a force or weight behind that speed, in the same way that a strong arm will not throw a strong punch without a great velocity. For this reason, knowing the difference between power and force is key in both boxing and physics.

Now, let's look at punching from the view of kinetic energy. Kinetic energy is the energy of motion, observable as the movement of an object, particle, or set of particles. Any object in motion has kinetic energy. The movement will be exerted by a body of mass not neglected and a rectilinear trajectory. This corresponds to the kinetic energy stored during the movement in the equation $E_c = ½mv^2$. The kinetic energy during the shock will be converted into deformation energy. The more energy, the more important the shock will be.

How do we store the most energy in the first place? Well, if the value of the mass is increased, the value of the kinetic energy increases; it is multiplied by the same factor multiplying the mass. If we multiply the speed, the value of the kinetic energy will be multiplied by the square of the factor multiplying the speed. It would therefore be more judicious to increase the speed of the punch, knowing that it allows a greater enlargement of the kinetic energy generated by this shot.

To increase speed is not only a matter of exercising a quick lever with the arm (a lever arm is the line perpendicular to the line of action to your reference point), but it is the whole body that is used to perform the movement. The boxer will try to give a punch storing as much kinetic energy as possible. For this, he will move his body as quickly as possible to gain maximum speed. This gain in speed will amplify the punch exerted by the boxer, which will generate more kinetic energy stored, and thus transmit a greater shock. For this, we must

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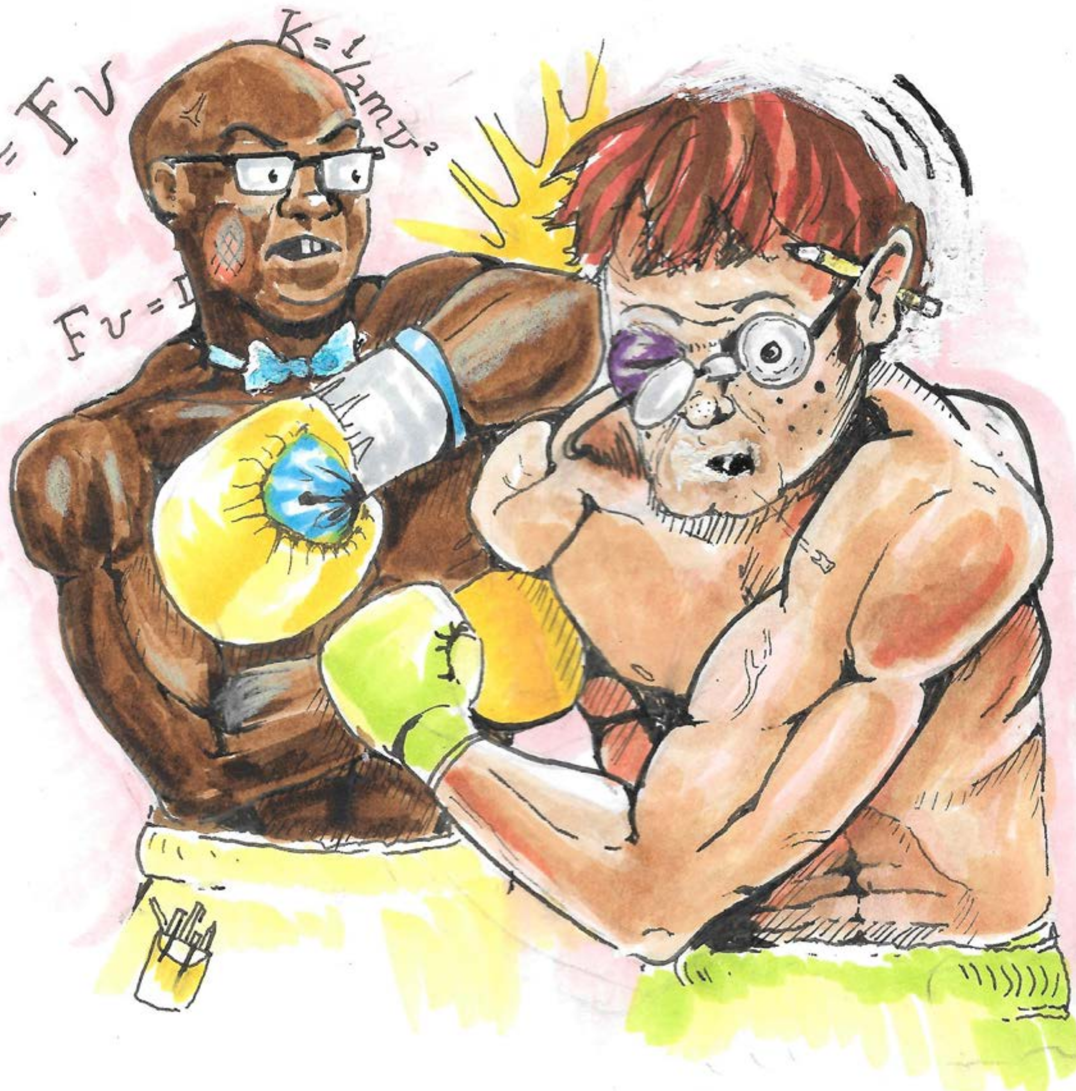
determine and work on the body parts that can be used to gain speed. It is important to know which joints can be used to make this move; some joints exercise movements that others cannot achieve. So, it is important to keep in mind that the whole body can be used to make the most powerful punch possible.



The most powerful punch starts at the level of the legs. They act like a spring by exerting a force on the ground. It is explained by Newton’s third law. Formally stated, Newton's third law is: For every action, there is an equal and opposite reaction. The more the boxer exerts a significant force on the ground, the more the ground will propel the body of the boxer forward, thus allowing the boxer to gain speed. According to Newton's second law of motion: Acceleration is produced when a force acts on a mass. The force exerted in return will create acceleration. The energy will then be amplified at the hips, which will rotate towards the opponent. The chest will do the same, as well as the shoulders, and the speed will be further amplified. Next, the muscle contraction in the arm is important to create the fastest movement possible. It will be placed at the back of the body when the boxer is in profile so that it has a greater margin of acceleration. As soon as the shoulders have finished their rotation, the arm will exert this movement of leverage amplified by all the displacement of the body, and it is at this point that the blow reached its pinnacle of speed.

In boxing, the concept of undulatory movement of the body and kinetic energy plays in a big role in developing the proper technique. An example given by my instructor of how a punch works is the example of the whip. Whipping a whip gives kinetic energy to the lash. This energy propagates along the lash to the other end of the whip, which we can refer to it as energy flux. The kinetic energy is then concentrated in the extreme end and the speed of the latter can exceed the speed of sound. Researchers have even observed that the speed of the end of the whip could be twice that of the speed of sound!

We have seen the physics of throwing a punch. Now let’s look at something on the other end: the physics of taking a hit in the face. When collisions happen, in this case between a boxing glove and the face of the opponent, the two concepts that come into play are momentum and impulse:

- Momentum is an object’s tendency to resist change in acceleration, and its formula is: *Momentum (P) = Mass * Velocity*.

- An impulse is the change in momentum of a certain object and is determined using the formula: *Impulse = Force * Time*.

Here again we can see that physics equations apply to boxing techniques. Trainers often know the strike force damage is caused by the speed of the arm multiplied by muscular and body weight. Using the physics equation of momentum, boxers know that they can improve their performance by increasing muscular mass. One of the most important techniques that one learns in boxing is moving the entire body to get the maximum force (weight) behind a punch, as mentioned in the previous paragraph. The trick is not to focus on moving your body a great distance, but rather to move it all at the same time. Moving your whole body one inch produces a much harder hit than moving your arm one foot. When a boxer hits his opponent, the momentum of the fist transfers to the face, which was previously stationary and had zero momentum. The steps of a punch explain the concept of conservation of momentum (when considering the two boxers as a system). Momentum refers to the motion that an object has. One of the most powerful laws in physics is the law of conservation of momentum. It tells us that the total momentum of a collection of objects (a system) remains unchanged. To reduce the impact of the punch on his face, the opponent boxer moves his head away. Even if the boxer is still hit, moving their head away increases the time interval in which the strike happens. Since it only takes a boxer a fraction of a second to throw a punch, a small reduction in the time interval can produce large results. However, the change in momentum or the impulse is still the same. By knowing how to exercise one’s strength while remaining relaxed, one will have mastered 99% of the striking technique. "Letting go" allows one’s shot to accelerate quickly by creating a devastating explosion when weight is added.

Physics is everywhere in our daily lives. I hope this article showed you how you can love physics by relating it to something you enjoy doing!