

Teachers' Questions: Physics

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1. When an attacker starts moving (e.g. throw a punch) they move their centre of mass forward. This has inertia and will obey Newton's first law. The centre of mass will keep moving in the same direction and at the same speed unless an outside force causes it to decelerate. To stop an attack by decelerating the centre of mass requires you to provide a force that will match the attacker's, or a weaker force for a longer time (following the equation change in momentum = force x time). Instead, a martial arts practitioner will step out of the way of the centre of mass and allow it to continue. They will turn their hips in front of the attacker, bending their knees so their hips are lower than the attacker's centre of mass. This places a relatively small force on the attacker but produces a moment, causing the attacker to begin rotating about their centre of mass. The attacker will fall towards the floor and hit the floor. By Newton's third law, the floor will exert a force on the attacker and decelerate their centre of mass.
2. Almost 80% of the mass of the Earth is made of oxygen, silicon and calcium. These elements have an equal number of protons and neutrons. In any atom, the number of protons equals the number of electrons. We therefore assume that the Earth is made up of atoms with 1 electron for every 2 nucleons. The mass of two nucleons plus an electron is $2 \times 1.674 \times 10^{-27} + 9.11 \times 10^{-31} = 3.349 \times 10^{-27} \text{kg}$. Electrons make up $(9.11 \times 10^{-31} / 3.349 \times 10^{-27}) \times 100 = 0.027\%$ of the mass of the Earth. The Earth has a mass of $5.97 \times 10^{24} \text{kg}$ so the mass of electrons on Earth is approximately $1.624 \times 10^{21} \text{kg}$. The same mass of anti-electrons (positrons) is required to annihilate them so the total mass annihilated is $3.248 \times 10^{21} \text{kg}$. The energy released is $3.248 \times 10^{21} \times (3.00 \times 10^8)^2 = 2.923 \times 10^{38} \text{J}$. The Fat Man atomic bomb dropped on Nagasaki in 1945 released 84TJ. The energy released by annihilating the world's electrons equals $2.923 \times 10^{38} / 84 \times 10^{12} = 3.5 \times 10^{24}$ times the energy released in the Nagasaki bombing.