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**Introduction**

With a multiplicity of physics topics to explore, comics provide the perfect avenue for engaging young students by intertwining pop culture and science education [1]. The physics may sometimes be wrong, but it is wrong in fascinating ways that force us to confront our hidden assumptions about the way the world works.

**Superman and Force**

Superman was the original comic-book superhero and he needs no introduction. In his first appearance (Fig. 1) we learn that he can lift a 1938 Chevy Master (1300 kg), leap 18°F of a mile (200 m), and outrun a 1938 Streamliner train (44 m/s). The explanation originally offered for Superman’s strength by his creators, Jerry Siegel and Joe Shuster, was that Superman is essentially a scaled-up version of an insect, which can support 100 times its own weight and jump many times its original length (Fig. 2).

What’s wrong with this argument? Living creatures have similar densities. Thus their weight is proportional to their volume, or \( W \propto L^3 \) (where \( L \) is their characteristic size). But their strength is only proportional to their cross-sectional area, \( S \propto L^2 \) (think of the area of a tree trunk, for example, or a person’s muscles). Thus, if Superman is 200 times larger than an ant, he will be 200\(^2\) = 40,000 times stronger, but weigh 200\(^3\) = 8 million times as much. If an ant can lift 100 other ants, Superman will only be able to lift 110 \times 40,000/8,000,000 = 0.5 people, or about 50 kg = 100 lbs (about what you can lift!).

**The Flash and Speed**

Flash is the fastest superhero. His physics is also surprisingly honest. In Fig. 3 we see him dealing with the problems of friction and air resistance that come along with his incredible velocity.

In Fig. 4, Flash saves twelve people, covering a distance of about 120 m during the 1 s that a small plane (moving at about 140 mph = 60 m/s) takes to fall 60 m to the ground. So his mean speed is 120 m/s. But he recovers direction each time he saves a person! Thus his acceleration during each rescue is \( a = \frac{dv}{dt} = \frac{240 m/s}{1(1129 s)} = 300 g \). Ordinary people cannot tolerate accelerations greater than 10 g, so Flash must have developed such a tolerance (and he will need to be careful not to subject the people he is rescuing to it).

In Fig. 5, we need to interpret Flash’s thoughts with a grain of salt when he says that his speed allows him to “defy gravity.” It is more that he hardly notices the effects of gravity. For instance, if he zooms up a wall with an initial velocity of 120 m/s, gravity will slow him by only 10 m/s after 1 s, or 120 m of travel, and 20 m/s after 240 m. He still reaches the top. How about Flash’s explanation of his ability to skip from cloud to cloud? We leave this as an exercise for the reader.

**Captain Marvel and Energy**

Captain Marvel has only exploded into popularity within the last decade, but this superhero has also had a long history in the comic-book world. Introduced as Carol Danvers in 1968, her unique ability to absorb and radiate energy has made her a standout character in recent years. Her fascinating powers (summarized in Fig. 6) can be utilized to introduce students to the concept of energy.

For example, in Fig. 6 (top left) Captain Marvel stops a rocky asteroid headed for Earth. Using a compass, we can find the radius of the asteroid. Using Carol Danvers’ height (5’11” = 1.8 m) as a scale, we find that \( r = 7 \text{ m} \). Assuming a typical rock density (2300 kg/m\(^3\)) we then find the asteroid’s mass to be \( 4 \times 10^7 \text{ kg} \). To stop this rock (initially moving at a typical interplanetary speed of \( v = 40 \text{ km/s} \)), Captain Marvel must do work equal to its change in kinetic energy. \( \Delta K = \frac{1}{2}mv^2 = 3 \times 10^{13} \text{ J} \).

Can she come up with that much energy? Yes! In Fig. 7, seeking energy for a different purpose, Captain Marvel converts the Sun into a white hole. As a rough estimate this would give her an energy of \( E = m_c c^2 = 2 \times 10^{53} \text{ J} \). It is not clear how she would harness this energy, but to put it in perspective we note that the energy used by the *entire planet Earth* in a year is 1.0 x 10\(^{17}\) TWh = 4 \times 10\(^{22}\) J. The above examples are only the smallest sliver of what is possible with superheroes, not only as entertainment, but as teaching tools in introductory physics. For more, we direct readers to Ref. [1].

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**References**