Superhero powers can teach students some strange stuff about science.

By Chris Jozefowicz

James Kakalios loved comic books when he was a kid but outgrew them as a teenager. Now a physics professor at the University of Minnesota, Kakalios has fallen in love with comics all over again. He even teaches a course at the university called Everything I Know About Science I Learned from Comic Books. In the course, Kakalios assigns comic books instead of textbooks to illustrate problems that science can solve. “Instead of inclined planes and pulleys, we use superheroes,” he says. He has put his lessons together in an entertaining new book titled The Physics of Superheroes.

UP AND AWAY!

No matter how outlandish a superpower might seem, a good scientific explanation often exists for what a superhero does with that power, says Kakalios. “First, I grant a character a one-time miracle exemption,” he says. The miracle exemption usually accounts for the existence of the superpower. Then the rest falls into place.

Take Magneto, the mutant master of magnetism from the X-Men comic books. He was born with the power to create and control magnetic fields, areas in which magnetic forces attract or repel objects. Normally, a magnet produces a magnetic field. But because Magneto is made of flesh and not magnets, his ability to create magnetic fields is his one miracle exemption, says Kakalios. Once readers accept that, they can turn to science to understand how Magneto uses magnetic fields during his adventures.

A nonmagnetic object becomes temporarily magnetized when it is placed in a magnetic field. Materials influenced in that way, such as iron, steel, and nickel, are called ferromagnetic. Magneto can move huge chunks of ferromagnetic metal by creating magnetic fields in and around the metal.

Magneto can levitate more than metal. He can levitate himself. Kakalios says Magneto’s magnetic powers could accomplish that, too. Living things are not magnetic or...
even ferromagnetic, but they can be influenced by magnets. The human body is mostly made of water, and water is **diamagnetic**. Something diamagnetic is not normally attracted to or repelled by a magnet. But a magnetic field that is superstrong—say, hundreds of times as strong as a refrigerator magnet—can repel something diamagnetic.

Magneto can create a superstrong magnetic field beneath him that lifts him off the ground by repelling all the diamagnetic water molecules in his body. Scientists in the Netherlands have done something similar, using strong magnetic fields and the properties of diamagnetism to levitate frogs and grasshoppers.

**ULTRAVIOLET VISION**

Sometimes a superhero seems to need more than one miracle. Sue Storm, the Invisible Woman from the *Fantastic Four*, is an example. Her miracle is her power to become invisible. But some fans of the *Fantastic Four* have correctly pointed out that Storm's invisibility should also rob her of her ability to see, so she might need another miracle.

Objects are visible to the human eye because they absorb and reflect light. An object becomes invisible when it lets light zip through her without interacting with her body at all. But then, as the fans have pointed out, she shouldn't be able to see.

Why not? The eyes function because they have lenses that focus light on special cells called rods and cones. When Storm becomes invisible, the rods and cones in her eyes would be unable to absorb visible light, and her eyes would stop functioning.

Does Storm need a second miracle to save her from blindness? Not necessarily, says Kakalios. Storm could be both sighted and invisible. She could do that if her body responded to ultraviolet (UV) light and let normal light pass through. UV light is a form of radiation from the sun—it tans and burns the skin—that we cannot see. If Storm reflected and absorbed only UV light, we couldn't see her either, but she could see us.

**SUPERBLOOPER**

Sometimes, comic books ask readers to accept too much, even after invoking Kakalios's one-miracle exemption. Take Scott Summers, better known as the *X-Men*'s Cyclops. Summers was born with the mutant ability to shoot a beam of “pure force” from his eyes. To stop that beam from blasting everything in sight, Cyclops must wear a ruby quartz visor.

Kakalios says that even if Cyclops could shoot a force beam from his eyes—that's one miracle—he would not be able to control it. His head would snap off. One of the fundamental laws of physics is that forces come in pairs, says Kakalios. That is *Newton's third law of motion*: Every action has an equal and opposite reaction. Whenever you push against something, it pushes back on you.

Cyclops's force beam should push back on his head with a force equal to the force of the beam. Because his beam is strong enough to suspend a 2-ton boulder in midair, the same amount of force should push back on Cyclops. That much force would accelerate Cyclops's head backward at several hundred miles per hour.

If Cyclops's powers include superstrong neck muscles, he breaks Kakalios's one-miracle rule. If Cyclops doesn't have strong neck muscles, he probably breaks his neck. Still, Kakalios manages to use the goof as a good example. “Cyclops has done enough good in the world,” he says, “so I'll forgive him.”