

### Physics (or the lack thereof) in Film

Movies often violate the fundamental laws of physics in order to increase the entertainment value of a film or to open up new possibilities in the plot of a film. As engaged viewers, we often suspend our disbelief of these violations of physics as we sink into the world of the film, only later, upon reflection, to realize certain aspects of a film are downright impossible. The goal of this project is to analyze scenes from films, both while suspending disbelief and while viewing critically, in order to discover examples in which the laws of physics are broken, to explore the motivation for breaking the laws of physics, and to consider what is done to promote the suspension of disbelief the audience engages in. Since the suspension of belief is so pronounced in certain types of films (super heroes, magic, etc), you must choose scenes that take place in a world with the same laws of physics as our own.

You will select TWO different scenes to analyze, examining the violation of TWO different laws of physics. Your analysis must include:

1. A brief description of the scene. It is necessary to explain what happens with enough detail so that I will be able to understand what happens in the scene even if I have never seen it before. There is no need to get bogged down in minute details that are unrelated to the physics, nor to explain elements of the plot that are unrelated to your analysis (more on this later).
2. A clear statement of which law or laws are broken and evidence that supports your statement that the law or laws are broken. A particularly effective way to do this is to state the law in equation form and approximate numbers. Be sure to explain why you choose your approximate values.
3. A brief explanation of why the filmmakers chose to break the laws of physics. How does breaking the laws of physics enhance the entertainment value of the scene/film? How does it contribute to or enhance the plot? How does it contribute to or enhance the style of the film? Etc.
4. A brief explanation of what the filmmakers do in order to help the audience suspend their disbelief of what is happening. Why does the audience accept the breaking of the laws of physics as plausible within the world of the film instead of causing the audience to reject the film as impossible?

Example:

In a scene from a Superman film, Lois Lane falls out of an airplane, saved only by Superman, who swoops in to catch her at the last second. Of note, the path of Superman's flight is perfectly horizontal before, during, and after the catch. While Superman himself exists beyond our laws of physics, Lois Lane does not, and yet what happens to her is in clear violation of the laws of physics. If Lois Lane fell with air resistance, her terminal velocity would be about 56 m/s (Wikipedia). Let us assume her mass to be about 50 kg. Since Superman's flight is perfectly horizontal, Lois Lane's vertically velocity changes from 56 m/s to 0 m/s very quickly. Since we cannot perform calculations with an impact time of 0, let us say the impact time is .01 s. (This is a generously large impact time, as Lois would have pushed Superman downward by 1/3 to ½ a meter in this time.) Applying the equation for impulse to Lois Lane, we see

$$\begin{aligned}
 Ft &= \Delta p \\
 Ft &= m(v_f - v_i) \\
 F &= \frac{m(v_f - v_i)}{t} \\
 F &= \frac{50 \text{ kg} (0 - 56 \text{ m/s})}{.01 \text{ s}} = -280,000 \text{ N}
 \end{aligned}$$

Given that "a sharp blow that delivers some 3,300 N of force has a 25% chance of cracking an average person's rib ([www.livescience.com/6040-brute-force-humans-punch.html](http://www.livescience.com/6040-brute-force-humans-punch.html)), we can safely say that the impact with Superman's arms would have deadly effects on Lois Lane. (Same in X axis...)

This scene also violates the law of conservation of momentum, which states that the momentum of a system remains constant. If we view the system of Lois Lane and Superman, then, before they collide, Lois Lane has momentum directed downward while Superman has momentum directed to the side (say the right). After the collision, Superman, now holding Lois Lane, has the same velocity. If momentum were conserved, Superman's trajectory would have been deflected downward, as Lois Lane had downward momentum initially; this downward momentum was lost. Furthermore, Superman's horizontal speed would have decreased, as catching Lois Lane increased the amount of mass moving to the right. Thus, there is a violation of conservation of momentum in both the x and the y axis. Consider the following, where Superman is 1 and Lois Lane is 2

$$\begin{aligned}
 p_{xi} &= p_{xf} \\
 p_{x1i} + p_{x2i} &= p_{xsf} \\
 m_1 v_{x1i} + m_2 v_{x2i} &= (m_1 + m_2)(v_{xsf}) \\
 \text{If } v_{x2i} = 0 \text{ and } m_1, m_2, v_{x1i} &\neq 0, \text{ then } v_{x1i} \neq v_{xsf}
 \end{aligned}$$

$$\begin{aligned}
 p_{yi} &= p_{yf} \\
 p_{y1i} + p_{y2i} &= p_{ysf} \\
 m_1 v_{y1i} + m_2 v_{y2i} &= (m_1 + m_2)(v_{ysf}) \\
 \text{If } v_{y1i} = 0 \text{ and } m_1, m_2, v_{y2i} &\neq 0, \text{ then } v_{ysf} \neq 0
 \end{aligned}$$

While the violations of physics involved with Superman catching Lois Lane are glaringly obvious once analyzed, they tend to go unnoticed while actually watching the movie. This is most likely because of Superman himself. The audience knows Superman is not bound by the laws of physics, and actually expects to see him break the laws of physics; they know he is a character of fancy and thus enter into the film with a strong suspension of disbelief. The filmmakers are able to extend this suspension of disbelief beyond Superman and onto the objects and people he encounters because the audience is so deeply engaged in the fantasy of Superman. This extension of the suspension of disbelief allows the

filmmakers to create more exciting scenes, as breaking the laws of physics opens up new possibilities for all characters and the environment itself.