Journal of Interdisciplinary Science Topics

Wolverine: The Force Behind His Train Lunge

David Evans
The Centre for Interdisciplinary Science, University of Leicester
24/03/2015

Abstract
Wolverine is arguably the most famous member of Marvel comics X-Men team and Hugh Jackman has become synonymous with the character having played him in 7 X-Men films to date, including 2013's "*The Wolverine*". Of this film's many fight scenes perhaps the most memorable was the scene where Wolverine fights a group of assassins whilst clinging onto the top of a high speed train. During this scene Wolverine releases his grip on the train several times and at one time does so to lunge at an enemy and kill him. This paper models that lunge and shows that Wolverine hit the assassin with at least 1300 N of force.

Introduction
Wolverine is arguably one of Marvels most famous characters and a member of the mutant comprised X-Men team. His mutant abilities give him heightened senses and regenerative abilities which allow him to heal from almost any wound and slow down the rate at which he ages. This meant that he could survive a military experiment where by the fictional indestructible metal Adamantium was grafted to his entire skeleton, including his distinctive bone claws. He can produce these claws from between his knuckles on both hands and uses them as weapons against his foes. These metal claws and the ability to heal help make Wolverine one of the world's most recognisable comic book characters [1].

Because Wolverine is such a popular character he has been included in all 7 of 20th Century Fox's X-Men based films, including 2 solo Wolverine films. In all 7 films Wolverine is portrayed by the actor Hugh Jackman who has become synonymous with the role which he first took on in 2000s "X-Men". 2013's "*The Wolverine*" marked Jackman's 6th portrayal of the character and the character's second solo blockbuster film [2].

The film is primarily set in modern Japan with Wolverine facing perhaps his toughest test ever in that his regenerative abilities have been dramatically slowed by an unknown poison. Throughout the course of the film Wolverine finds himself deep within a conspiracy involving Japan's most high profile and influential families which ultimately puts him in a variety of dangerous and due to the absence of his regeneration, life threatening situations [3].

One scene during the film sees Wolverine fighting a group of assassins whilst on top of a high speed train. In the scene the assassins are attempting to kill Mariko, Wolverine's love interest in the film. Wolverine confronts them before they reach her in the train but cuts the side of the carriage causing them all to fly out of the side. Several of the fight's participants, including Wolverine, cling frantically to the sides and roof of the train and a memorable fight scene ensues. During this Wolverine let's go of the train and the train's momentum causes him to be propelled forward into one of the assassin's chest. He lunges claws first and stabs the assassin before throwing him from the train. While watching this lunge one is left to wonder exactly how hard Wolverine is actually hitting the man as he files through the air. This paper attempts to determine the force Wolverine lunges with during this memorable train fight scene [3].

Accounting for the Adamantium
In order to establish the force with which he lunges, Wolverine's total mass must be considered. This means accounting for the Adamantium, which as mentioned previously was fused to his skeleton during a military experiment. To do this it was

assumed that Wolverine's entire skeleton was metal and that no bone remained at all. Because Adamantium is a fictional indestructible metal it was modelled as Osmium, the densest know metallic element (density of 22,500 kgm^{-3}) [4]. Adamantium is considered to be a very dense and indestructible metal so it made so the densest known metal was chosen for this model. To calculate Wolverine's mass with an Osmium skeleton his mass without a skeleton was established first. Assuming that Wolverine's mass with a bone skeleton was the same as Hugh Jackman's (82 kg) [5] and that 15% of that mass was skeleton (including the claws) [6] then Wolverines mass without a skeleton could be calculated as 69.7 kg. Using this value and the density of bone (2000 kgm^{-3}) [7] the volume of Wolverine's skeleton could be calculated as follows:

$$Volume = \frac{mass}{density} = \frac{12.3}{2000} = 6.15 \times 10^{-3}\, m^3$$

Using the volume of Wolverine's skeleton and the density of Osmium the mass of Wolverine's modelled metal skeleton can then be calculated:

$$mass = 22500 \times\ 6.15 \times 10^{-3} = 138.4\, kg$$

Once this is added to Wolverine's mass without a skeleton his total mass is found to be 208.1 kg.

Modelling the Lunge

Now that Wolverine's mass has been calculated it is possible to model his lunge on the train. Because Wolverine and his target are moving at high speed on top of the train the actual mechanics of the incident in question are very complex. Therefore in order to simplify the model the motion of the train will not be considered. Based on observations of the scene in question, it will be assumed that Wolverine lunges a distance of 50 m towards the target and that he accelerates towards him in a straight line over a time period of 4 s. This allows Wolverine's final velocity to be calculated from the following equation of motion [8]:

$$s = \frac{(u+v)t}{2},$$

So:

$$v = \frac{2s}{t} = \frac{2\,x\,50}{4} = 25\, ms^{-1}.$$

From this final velocity and another equation of motion Wolverine's acceleration can then be calculated [8]:

$$v^2 = u^2 + 2as,$$

So:

$$a = \frac{v^2 - u^2}{2s} = \frac{25^2}{2x50} = 6.25\, ms^{-2}.$$

Finally using $F = ma$ the force of Wolverine's lunge can be calculated from his mass and his acceleration:

$$F = ma = 208.1 \times\ 6.25 = 1300.6\, N$$

Studies have shown that the force required to pierce human skin is relatively small (within the range of 35–55 N) [9] and work by Hainsworth et al. has shown that sharp kitchen knives have the ability to penetrate skin analogues with a hardness range of 125–155 N [10]. Considering that Wolverine lunges at the assassin claws first, and his claws are portrayed as highly sharp blades it seems reasonable to assume that Wolverine hitting the assassin with 1300N of force would be more than sufficient to penetrate the skin and to stab him in the chest.

Conclusion

During the train fight scene Wolverine is seen to lunge at an enemy claws first and stab him in the chest. This simple model shows that Wolverine hit the assassin on top of the train with at least 1300 N of force. When you consider that if a mass equal to Wolverine's modelled mass fell to the ground purely under the influence of gravity it would hit the ground with around 2041 N of force, this calculated value for the lunge force seems reasonable. In reality the force Wolverine hits with is likely to be different due to the motion of the train upon which the attack takes place. It's also possible that Wolverine's mass could be too high since this was based on the densest known metal because the actual indestructible metal which makes up his skeleton doesn't exist.

However the model clearly shows that the force Wolverine hit the assassin with is more than sufficient for Wolverine's famous Adamantium claws to penetrate the assassin's skin and stab him in the chest. Considering that Wolverines claws are around 20–30 cm in length, it's likely that in hitting him plain in the chest Wolverine could have penetrated some of the assassins major organs, for example the lungs. Therefore Wolverine lunging with this force claws force could clearly do potentially fatal damage to the assassin. And it the stab wounds didn't prove fatal, Wolverine throwing the assassin from the high speed train after the lunge probably finished the job.

References

[1] Marvel (2015) *Wolverine (James Howlett)*. Marvel. Available: http://marvel.com/characters/66/wolverine [Accessed 19/03/2015].

[2] IMDb (2015) *Hugh Jackman.* IMDb, Actor Profile. Available: http://www.imdb.com/name/nm0413168/ [Accessed 19/03/2015].

[3] Mangold, J., Bomback, M. & Frank, S. (2013) *The Wolverine*. 20th Century Fox.

[4] Ho, K. (2007) *Density of Osmium*. Available: http://hypertextbook.com/facts/2007/KarmenHo.shtml [Accessed 19/03/2015]

[5] HealthyCeleb (2015) *Hugh Jackman Height Weight Body Statistics*. HealthyCeleb. Available: http://healthyceleb.com/hugh-jackman-height-weight-body-statistics/7398 [Accessed 19/03/2015]

[6] Microlife (2014) *Obesity in the medical sense is an excess of body fat!* Microlife Corporation. Available: http://www.microlife.com/products/weightmanagement/ [Accessed 19/03/2015]

[7] Engineering ToolBox (2015) *Densities of Miscellaneous Solids.* Available: http://www.engineeringtoolbox.com/density-solids-d_1265.html [Accessed 19/03/2015]

[8] Tipler, P.A. & Mosca, G. (2008) *Physics for Scientists and Engineers, 6th Ed.* NY: W.H Freeman and Company.

[9] O'Callaghan, P.T., Jones, M.D., James, D.S., Leadbetter, S., Holt, C.A. & Nokes, L.D.M. (1999) *Dynamics of stab wounds: force required for penetration of various cadaveric human tissues*. Forensic Science International, 104, 2-3, pp. 173–178.

[10] Hainsworth, S.V., Delaney, R.J. & Rutty, G.N. (2008) *How sharp is sharp? Towards quantification of the sharpness and penetration ability of kitchen knives used in stabbings.* International Journal of Legal Medicine, 122, 4 pp. 281–291.