Flipping Physics Lecture Notes:

Proving and Explaining Impulse Approximation

This video is an extension of "Impulse Introduction or If You Don't Bend Your Knees When Stepping off a Wall". We determined the force of impact when stepping off the wall for two different cases:

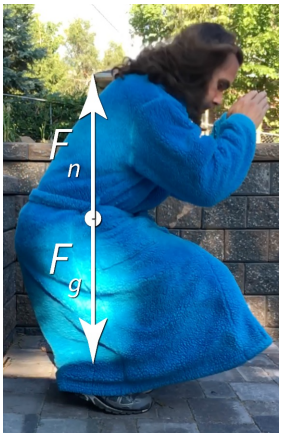
1) Bent knees: $\sum \vec{F}_{bent} = \frac{\Delta \vec{p}}{\Delta t} = 988.03N \approx 990N$ [♥]

2) Not bent knees: $\sum \vec{F}_{not\ bent} = \frac{\Delta \vec{p}}{\Delta t} = 11065.93N \approx 11000N$ [♠]

In order to say the force of impact during the collision was equal to the net force during the collision, we needed to use the Impulse Approximation.

Impulse Approximation: During the short time interval of a collision, the force of impact is much larger than all the other forces, therefore we can consider the other forces to be negligible when compared to the impact force and the net force is approximately equal to the force of impact.

This begs the question, was this actually true in these two examples? Let's find out:



In order to determine the force during impact we need to draw a free body diagram:

The force of impact is caused by the ground on my body and is the Force Normal:

$$\sum F_y = F_N - F_g \Rightarrow F_N = \sum F_y + F_g = \sum F_y + mg$$

We can solve for the force of impact (the force normal) during both instances.

Bent knees: $F_N = 988.03 + (73)(9.81) = 1704.16N$

Not bent knees: $F_N = 11065.93 + (73)(9.81) = 11782.06N$

And how far off were these forces of impact from when we used the Impulse Approximation?

Bent knees: $E_r = \frac{O - A}{A} \times 100 = \frac{988.03 - 1704.16}{1704.16} \times 100 = -42.022 \approx -42\%$

Not bent knees: $E_r = \frac{O - A}{A} \times 100 = \frac{11065.93 - 11782.06}{11782.06} \times 100 = -6.0781 \approx -6.1\%$

In other words, with a time interval of 0.28 seconds when bending my knees, the Impulse Approximation was 42% off, which is, in my opinion too much! And we probably shouldn't have done so!

Also, the shorter the time interval, the larger the force of impact relative to the net force, and therefore the more appropriate it is to use the Impulse Approximation.

[♥] If you want to see all of the numbers behind this calculation, please visit: http://www.flippingphysics.com/impact-force-problem.html

[♠] If you want to see all of the numbers behind this calculation, please visit: http://www.flippingphysics.com/impulse-introduction.html