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P3_11 Spartan Rocket Jump

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Abstract
This paper aims to find the height reached when a rocket propelled grenade is fired vertically downward by Master Chief, from the game Halo, whilst he is at the peak of his jump. In order to do this the conservation of momentum and energy from the explosion are considered. The height of the rocket powered jump was calculated to be 93.8m.

Introduction
In first person shooter video games the player is often able to jump to a large height by firing a rocket at their feet whilst jumping, this process propels the character several meters into the air allowing them to access higher levels quickly. One of the main aspects neglected in this process is the damage to the character from the explosion below them which in reality would kill anyone who tried to do it; this can often be explained by shields or heavy armour. This article aims to find the height Master Chief from the Halo series [1] could reach.

Theory
When an RPG (Rocket Propelled Grenade) is fired vertically downwards whilst in the air, two main factors need to be considered to calculate the height achieved by the person. Firstly it is necessary to consider conservation of momentum,

$$m_1 v_1 = m_2 v_2 \,, \tag{1}$$

where momentum is equal to mass, m, multiplied by velocity, v, m_1 and m_2 are the mass of the person plus the mass of the launcher and the rocket mass respectively, v_1 and v_2 are the velocities of the person and rocket respectively. In this scenario the momentum of the rocket travelling downwards must be equal to the momentum of the person firing travelling upwards, it is also necessary to assume that the RPG does not have any recoil dampening, although most current devices do in order to make firing one more comfortable.

Secondly, the energy from the explosion will impose a force on the person; it will be assumed that all of the energy that hits the person's feet will be converted into kinetic energy giving the person an instantaneous velocity. The kinetic energy obtained will therefore depend on the portion of energy from the explosion that hits the person's feet,

$$K = \tfrac{1}{2} m_1 {v_3}^2 = \frac{A E_{ex}}{4\pi R^2} \,, \tag{2}$$

where K is kinetic energy, A is the area of the feet in, v_3 is the velocity, E_{ex} is the energy released from the explosion in joules and R is the distance between the feet and the ground. It is assumed that the energy is distributed equally in all directions.

By rearranging equations 1 and 2, for v_1 and v_3 respectively, and adding the two rearranged equations together the total velocity, v_f, is found to be

$$v_f = v_1 + v_3 = \frac{m_2 v_2}{m_1} + \sqrt{\frac{A E_{ex}}{2\pi R^2 m_1}} \,. \tag{3}$$

The height to which the person will rise, x, can then be found using,

$$x = -\frac{{v_f}^2}{2g} + R \,, \tag{4}$$

where g is the acceleration due to gravity, taken to be $-9.81ms^{-2}$, this is negative as it is towards the ground. For the purpose of this estimation, the effects of air resistance have been neglected and only the force of gravity is considered to be acting on the body, giving an acceleration of g.

Discussion

For the purpose of this article it will be assumed that Master Chief from the Halo series, who's mass is 500kg [2], is firing an RPG-29 vertically downwards after jumping to a height, R, of 0.5m. An RPG-29 has a loaded mass of 18.1kg, an unloaded mass of 12.1kg and a muzzle velocity, v_2 of $280ms^{-1}$ [3]. The masses m_1 and m_2 are therefore 512.1kg and 6kg respectively.

The rocket is assumed to have the same energy release per kg as TNT, $4.184MJkg^{-1}$ [4], and its whole mass to be accounted for by explosives, giving the energy released by the explosion, E_{ex}, to be, 25.1MJ. The area of a foot has been estimated to be $0.025m^2$ giving a total area, A, of $0.05m^2$.

When the numbers are substituted into equation 3 a velocity, v_f, of $42.8ms^{-1}$ is obtained. When this value is put into equation 4, the height reached is found to be 93.8m.

Conclusion

Although it is unlikely somebody with armour as advanced as the Master Chief's would be using an RPG-29, it is clear that the tactic would produce a very significant result, raising the Master Chief to a height of nearly 100m. It is however very unlikely that such a method would be possible for a person without sufficient protection.

In addition to the explosive damage, a fall of 93.8m would do significant damage to any person without the protection afforded to Master Chief by his armour, as he is seen in Halo 3 to fall down from around 2km onto planet's surface [5].

References

[1]*Halo*, Bungie (Developers), 2001.
[2]http://Halo.wikia.com/wiki/MJOLNIR_Powered_Assault_Armor accessed on 20/11/2012
[3]www.militaryfactory.com/smallarms/detail.asp?smallarms_id=487 accessed on 20/11/2012
[4]http://physics.nist.gov/Pubs/SP811/appenB8.html accessed on 20/11/2012
[5]*Halo 3*, Bungie (Developers), 2007.