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P4_5 Spartan Rocket Jump Revised

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Abstract

In this paper, we have expanded on an idea from a previous PST paper: $P3\_11$ Spartan Rocket Jump (2012). We consider the horizontal distance travelled by Master Chief if he performs a rocket jump. By using the equations of motion, we determined the maximum horizontal distance Master Chief could travel as 106 m, relating to an optimal vertical angle that a RPG round can be fired from as being about 30.0°.

Introduction

In this paper, we will be elaborating on work done previously by [1], where they have considered the vertical distance travelled by Master Chief (M.C.), from the Halo series of video games, through the means of rocket jumping. This is where somebody jumps and fires a RPG (rocket propelled grenade) towards the ground, using the resulting explosion as a means of propulsion.

In [1], they have only considered how far M.C. would travel in a straight line vertically upwards, however we believe rocket jumping is predominantly for horizontal travel. Therefore, we will be expanding on the physics from this paper to find the maximum distance M.C. could travel horizontally if a rocket jump were to be performed.

Theory

A rocket jump requires a normal jump to be performed first, which raises M.C.'s distance off the ground to h. Secondly, M.C. would have to aim the RPG down towards the ground at an angle θ perpendicular to the ground, as shown in

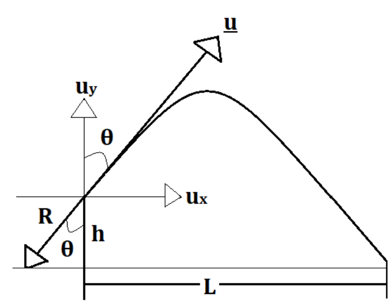

Figure 1: A diagram we have produced showing the RPG round's direction R at an angle θ to the vertical direction, when M.C. is at a distance h above the ground.

Figure (1). At the distance h off the ground, plus when M.C. has fired the RPG round, a subsequent explosion will occur at a distance R away from M.C.'s position. We will be assuming the explosion will release energy in an isotropic spherical distribution and the RPG round has negligible travel time. Therefore, the kinetic energy E_K the M.C. will gain is given by [1]:

$$E_K = \frac{1}{2}mu^2 = \frac{AE_{exp}}{4\pi R^2},\ u^2 = \frac{AE_{exp}}{2\pi m R^2}, \qquad (1)$$

where m is the mass of M.C., u is the subse-

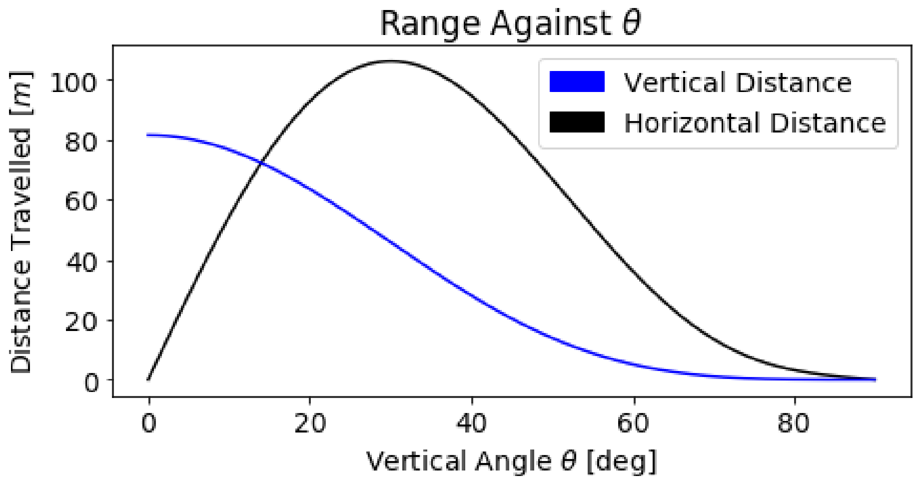

Figure 2: A plot we have produced showing the vertical and horizontal distances travelled for varying θ angles.

quent velocity of M.C., A is the projected area of M.C. from the distance R and E_{exp} is the energy released from the RPG round's explosion. From Equation (1), we can use the trigonometric relation R = h/cos(θ) to obtain:

$$u = \sqrt{\frac{AE_{exp}}{2\pi m}\,\frac{cos(\theta)}{h}}. \tag{2}$$

We will be using values of $A = 0.05\ m^2$, E_{exp} = 25.1 MJ, $h = 0.5\ m$ and $m = 500\ kg$, directly from [1]. After the explosion, we will assume M.C. undergoes an instantaneous acceleration, giving him a velocity equal to u. Therefore, M.C. will undergo parabolic (projectile) motion, with only gravity acting on him vertically downwards.

This means we can use equations of motion to describe the range: $L = u_x t$, where $u_x = usin(\theta)$ and t is the duration of the parabolic motion. We are trying to find the angle θ for which L is a maximum.

The time t taken to complete the parabolic path will be considered by using Equation (3) below, where we know $u_y = ucos(\theta)$, a = -9.81 ms^{-2} and s = -0.5 m. Therefore:

$$s = u_y t + \frac{1}{2}at^2,\ \frac{9.81}{2}t^2 - ucos(\theta)t - \frac{1}{2} = 0, \tag{3}$$

which is a quadratic equation in t, so will have a positive t solution of (by using the quadratic formula):

$$t = \frac{ucos(\theta) + \sqrt{u^2cos^2(\theta) + 9.81}}{9.81}, \tag{4}$$

which can then be used to find $L = usin(\theta)t$.

Results

We have decided to use Python to determine the numerical solution to this problem, by varying θ from 0 to $\pi/2$ *radians*. We generated a range of u, t and L values dependent on θ. Using this numerical method, we have determined; $u = 34.6\ ms^{-1}$, $t = 6.13$ *seconds*, $L = 106\ m$ and $\theta = 0.523$ *radians*, or around 30.0°.

Conclusion

Overall, we have determined the angle M.C. must fire an RPG round at in order for him to go the furthest horizontal distance possible, which we found to be about 30.0°. A major problem with this mode of transportation is that it will be deadly for the user, therefore we acknowledge the lack of feasability of this happening in reality. An area of future study may be to include how air resistance would affect the horizontal distance travelled, as well as how inclined surfaces may affect the optimal angle θ, as we have only considered a flat plane.

References

[1] A. Clark et al. *P3_11 Spartan Rocket Jump*, PST 11, (2012).