**GAME2005 Assignment 1 Physics Report**

**The Problem:** “Over a completely flat surface a thermal detonator (Star Wars) is thrown by a wookiee (a member of the rebel alliance) towards a group of imperial stormtroopers. The thermal detonator always leaves the wookiee’s hand with a speed of 95m/s and the thermal detonator has a mass of 2.2Kg”

**Part a)** “Suppose that the Stormtroopers are 485m away*. What is the correct angle for the wookiee to throw the thermal detonator so that it reaches the Stormtroopers*.”

We can start by gathering information. Based on the question, we know that this is a type 2 projectile motion problem, so the equation we will use is . Because the projectile starts and is thrown on flat ground, , both of which are 0. Our initial throwing velocity is 95, and we already know gravity is 9.8. We need to re-arrange the first equation to solve for the value in question, our angle, which we will represent as theta ().

In addition to solving our angle, we also need to find a way to remove the unknown variables from our equation, time and the y velocity (), while somehow introducing theta to the equation. We can solve both of these issues by introducing the substitution method to our equation. We can get rid by simply substituting it with the equation , like so:

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By substituting in the new equation, we have now introduced theta into the equation to solve it, and added another value that we know, to the equation, being the initial velocity. However, before the equation is re-arranged, we need to find a way to substitute time, since it’s an unknown value. We can use the equation , since it doesn’t introduce any variables we don’t know, and re-arrange it for time: . We can now substitute this equation in:

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With the unknown variables out of the way, and after some value cancelations, the equation can now start to be re-arranged to solve theta. However, we first have to get rid either *sin* or *cos* from the equation and use the other to solve theta. We can do this using trigonometric properties, although we will have to continue to re-arrange the equation. We will start this whole process off by equating the 2 terms in the equation to each other, by bring one term over the equal sign, and changing the term’s sign, which is why the final y position () was changed to 0:

To help simplify the equation, we will do cross multiplication on the terms in order to get rid of the fractions. After which, we can cancel out of some extra values by dividing each side by that value, since they both equate to each other:

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After re-arranging, a trigonometric identity forms: . This pattern is crucial because we are able to simplify it to its counterpart: . This would only leave *sin* as the only trigonometric function in the equation, which we can utilize to find theta. All that is left to is finish re-arranging the equation as such:

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With the equation now properly arranged, we can now solve for theta by filling in the rest of the values:

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It may seem we are done, however, there is a second possible angle to this problem: the complementary angle of 15.88963°. This is because the complementary angles in a projectile equation have the same range, with different times. However, because time was not given, it was not considered during the equation, resulting in 2 solutions. We can find this solution by simply subtracting theta from 90° like so:

Therefore, Wookiee must throw the thermal detonator at an angle of about or at a velocity of 95m/s in order to hit the stormtroopers that are 485m away.

**Part b)** *What is the maximum distance the thermal detonator could travel?*

Just like before, we start by gathering information. We already know the initial velocity of the thermal detonator of 95m/s, as well as the starting and final y positions, both 0. We now we need to find the maximum distance that the projectile can travel (). Thanks to complementary angles, we know that that maximum distance a projectile can travel is when it’s throwing angle () is 45°. This means we do not have to go through the process of finding theta, and only focus on the distance thrown. The equation will be key in finding this value, but we need to find the time first before we can solve it. Looking back at the equation , we can use this to isolate time and solve it. However, we do not need to substitute the equation, as we already have all the values needed to solve for time. We just need to fill in the values and re-arrange the equation as such:

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After plugging in the values and simplifying, this equation is now in the form of , which is a quadratic equation. This means that we are able to solve for time by using the quadratic formula:

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We are now required to solve both solutions from the equation:

Solution 1:

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Solution 2:

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What the quadratic formula has told us is the time that the projectile vertical distance (y), is at 0. This happens at two different times: when the projectile has begun flight (0s), and when the projectile has hit the ground (13.70942s). Therefore if we plug the time into the equation for horizontal distance (, we will find out how far the thermal detonator flew before it hit the ground:

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Therefore, the maximum distance the thermal detonator could travel is about 920.93227m