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## A3_4 Tree-location


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**Abstract**

In this paper it is explored whether or not the food items available to eat in the Nintendo game 'Animal Crossing: New Horizons' contain enough energy for the character to be able to dig a tree out of the ground, assuming that they already have the muscle mass to do so. It is found that the total work done to lift the tree out of the ground is $18.66kJ$, meaning that each variety of food within the game is able to provide enough energy to lift the tree.


### Introduction

In the popular game 'Animal Crossing: New Horizons', players have the ability to terraform and decorate their islands to personalise them and show friends and others around the world. One way that players can do this is to relocate the trees that grow there. To have this ability, players must eat one of the pieces of food available within the game and then use a shovel to dig up the tree and place it into their pocket. As it is eating the fruit which gives the player the ability, it can be assumed that the fruit itself has enough energy within it to lift the tree. This paper investigates whether there is enough energy within each food to achieve this, assuming that the player's character has the muscle mass to be able to achieve this and that all the energy from the fruit is used for lifting the tree.

### Theory

To calculate the total energy needed to dig tree out of the ground, first the mass of the tree needs to be estimated. To do this, approximations must be made to compare different items within the game and give them a real-world size.

When comparing the height of the tree to the character model, the tree stands at approximately 2 times the height of the player. As the height of both the male and female character models are the same, the mean is taken of the average height of a human male and a female [1], giving the character height as $1.65m$ tall and thus a tree height of $3.30m$. As the in-game item is listed as a 'hardwood tree', it was assumed that this can be compared to an oak tree. The assumption is also made that oak trees grow linearly and that its height is directly proportional to its mass so that the tree mass can be found by calculating a scaling factor.

From here, the system divides into two processes. Firstly, lifting the tree so that the spade becomes parallel to the ground, and secondly, lifting the tree from the ground to approximately $\frac{1}{2}$ of the character's height into their pocket. Both scenarios model the system as if they are using a lever to move a point mass, giving equation 1 as the force exerted by the character.

$$F_r = \frac{F_L d_L}{d_r}, \tag{1}$$

Where $F_r$ is the required force, $F_L$ is the force exerted by the load, $d_L$ is the distance from the load to the pivot and $d_r$ is the distance from the required force to the pivot.

Though, in the second scenario, the pivot of the system moves to the centre of the shovel. This means that $d_L$ and $d_r$ will be equal, as well as the force exerted and the weight of the tree.

Once the exerted forces are calculated, equation 2 can be used to find the work done in each scenario and these can be added together to find the total work done of the process.

$$W = d \text{ x } F \tag{2}$$

Where $d$ is the distance that the force is travelling and $F$ is the force being moved.

This is then compared to the energy within the foods by converting the calories within each one to $kJ$, using 1 calorie is equal to $4.184kJ$ [2].

**Calculations and Results**

In reference [3], an oak tree is found to be $23.9m$ tall and have a mass of 14.385 tonnes. By dividing the mass by the height, it is found that for every $1m$ the tree grows, its mass increases by $601.88kg$. If the assumptions made in the theory section are used, this gives our tree a mass of $1986.20kg$ and thus a weight of $19484.75N$.

The length of the spade is taken to be about $\frac{2}{3}$ of the height of the character, giving it a length of $1.10m$. The head of the spade is then taken to be $\frac{1}{3}$ of the overall spade length, with the rest being the shaft and handle. This gives $d_L = 0.37m$ and $d_r = 0.73m$ when substituted into equation 1. Using these values with the weight of the tree gives a final exerted force of $9875.77N$.

Next, the distance that the tree travels so that the spade becomes parallel with the ground must be calculated. This is done using simple trigonometry and an assumed entry angle of 45°, giving the travelled distance as $0.262m$.

Finally, the work done in each scenario is calculated using equation 2.

$$W_1 = 0.262 \text{ x } 9875.77 = 2.59kJ, \tag{3}$$

$$W_2 = 0.825 \text{ x } 19484.75 = 16.07kJ, \tag{4}$$

The total of these being the total energy required by the system:

$$W_T = 18.66kJ \tag{5}$$

| Fruit | Calories | Energy ($kJ$) | No. of trees able to be lifted |
|---|---|---|---|
| Apple | 94.6 | 395.80 | 21 |
| Two cherries | 10.40 | 43.52 | 2 |
| Orange | 69 | 288.70 | 15 |
| Coconut | 388 | 1623.39 | 87 |
| Pear | 101 | 433.60 | 23 |
| Peach | 68 | 284.51 | 15 |
| Turnip | 26 | 108.78 | 5 |

Table 1: Energy contained within each of the foods in Animal Crossing: New Horizons [4]

As can be seen in the table, every available food has a larger energy content than the amount that would be needed to dig up the tree.

**Conclusion**

In conclusion, there is more than enough energy within each food to provide the character with enough energy to lift the tree. Though, this conclusion is not entirely realistic as this paper assumes that there is 100% energy transfer from the fruit to the character, as well as making the large assumption that the character already has the muscle mass to lift the tree.

**References**


[1] `https://www.worlddata.info/average-bodyheight.php` [Accessed 1 November 2021]

[2] `https://www.bupa.com.au/healthlink/health-tools/convert-kilojoules-to-calories` [Accessed 1 November 2021]

[3] `https://sylva.org.uk/oneoak/tree_facts.php` [Accessed 1 November 2021]

[4] `https://www.nutritionix.com/` [Accessed 1 November 2021]