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MCD4270 Engineering Design

Trebuchet

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Task 1

A trebuchet is a sort of catapulting device that was commonly used as a siege engine. It features a long arm, sling, and projectile. The actual working mechanism behind the trebuchet starts at the counterweight. It is connected to the long arm which is connected to a frame that is stationary on the ground. On the other end of the long arm is the short arm, which is angled slightly from the long arm and on the short arm there is a sling which holds a projectile. As gravity pulls down the counterweight, the imbalance causes the long arm to rotate, which then causes the short arm to follow, as well as the sling. The rotational energy causes the projectile to swing, until it is released by the short arm. When it is released, the energy transferred by the counterweight to the projectile allows the projectile to be launched with a lot of energy.

The scientific principles behind a trebuchet include the gravity acting on the counterweight, the rotational energy acting from the counterweight through the arm, the rotational energy of the arm acting on the sling and all that energy gets converted to kinetic energy for the projectile, depending on the mass of the projectile, the energy may differ. There are multiple variables that can affect the performance of a trebuchet. However, the main elements would be the counterweight mass, projectile mass, and sling length.

Task 2

Sling Length (mm)	Counterweight Mass (grams)	Projectile Mass (grams)	Range (meters)	Maximum Height (meters)
250	520	6	5.8	1.5
225	520	6	4.6	1.3
250	520	12	3.4	1.1
200	520	6	3.2	1
250	260	6	2.9	1
225	520	12	2.6	0.9
250	520	17	2.1	0.9
225	260	6	2	0.8
200	520	12	1.6	0.7
200	260	6	1.4	0.7
225	520	17	1.4	0.7
200	260	12	0.9	0.6
200	260	17	0.8	0.5
225	260	17	0.8	0.6
250	260	17	0.8	0.6
200	520	17	0.7	0.6
250	260	12	0.6	0.6
225	260	12	0.1	0.6

Table 1 – All possible trebuchet configurations for the given variables sorted from highest range to lowest range.

From table 1, we can see that there is an overlapping between the variables, the range and maximum height of the projectile depends on all the variables combined which leads in surprising results. For example, for the case of the best results, the longest sling length, largest counterweight mass, and lowest projectile mass leads to the highest range and maximum height. However, the worse results were given by the middle sling length, lowest counterweight mass, and middle projectile mass. The lowest sling length, lowest counterweight mass, and higher projectile mass performs better relative to the lowest performing trebuchet configuration and some others.

Sling Length (mm)	Counterweight Mass (grams)	Projectile Mass (grams)	Range (meters)	Maximum Height (meters)
250	520	6	5.8	1.5
225	520	6	4.6	1.3
250	520	12	3.4	1.1
200	520	6	3.2	1
250	260	6	2.9	1
225	520	12	2.6	0.9
250	520	17	2.1	0.9
225	260	6	2	0.8
200	520	12	1.6	0.7
200	260	6	1.4	0.7
225	520	17	1.4	0.7
200	260	12	0.9	0.6
200	260	17	0.8	0.5
225	260	17	0.8	0.6
250	260	17	0.8	0.6
200	520	17	0.7	0.6
250	260	12	0.6	0.6
225	260	12	0.1	0.6

Table 2 – All possible trebuchet configurations colour coded (green = best, yellow = middle, red = worst).

If we were to colour code the variables, we can see a pattern that would not be obvious if only viewing table 1. If we were to look at data points 4, 5, and 7, the projectile mass alone (if all other variables were controlled) affects the range and maximum height of the projectile the most, followed by the counterweight mass, and the sling length. However, since there are multiple variables, a combination between the middle sling length and middle projectile mass affects the range and height of the projectile more than the counterweight mass alone.

Required Range (m)	Sling Length (mm)	Achieved Range (m)	Error (%)	Max Height (m)
3	0.252	2.9	3%	1
4.5	0.224	4.5	0%	1.3
6.5	0.252	5.9	9%	1.5

Table 3 – Achieved range vs required range with the sling length.

Required Range (meters)	Sling Length (mm)	Achieved Range (meters)	Releasae Angle	Projectile Mass (grams)	Counterweight Mass (grams)	Additional Mass Required (grams)
7	200	7	35	6	4200	3680
7	225	7	35	6	1130	610
7	250	7	35	6	700	180

Table 4 – Additional mass required for the projectile to reach 7 meters.