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Aggarwal

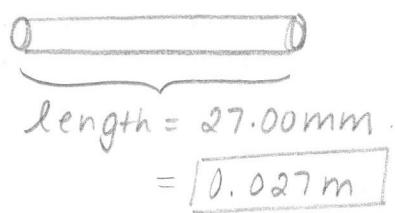
Constructing the Eiffel Tower using Geomags

- ① The Eiffel tower consists of 18,038 pieces, but I was unable to find the dimensions of each of these pieces.
- ② For my first attempt, I tried to stack up the geomags on top of each other by creating a cube shape using the geomags. However, this process didn't work well because I couldn't account for the 54° angle.
- ③ My second approach provides a much more accurate description as to how to build the Eiffel tower using geomags while simultaneously accounting for the 54° angle.
 - One problem with this approach is that we are ignoring the overlap of geomags breadth-wise

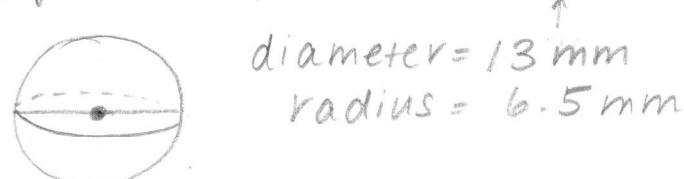
Assumptions: I am just constructing raw structure and not taking into account the steps, the platforms, lights, railings for the platforms, and the antenna.

Geomag Dimensions.

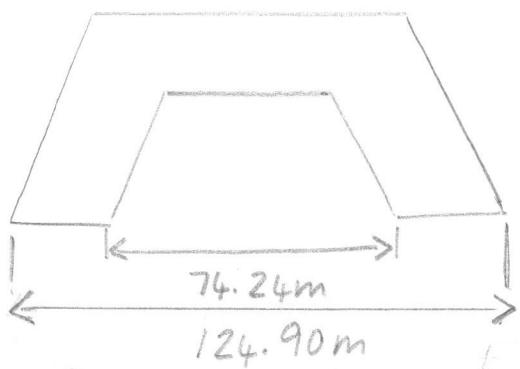
Geomag Rod



Geomag Sphere

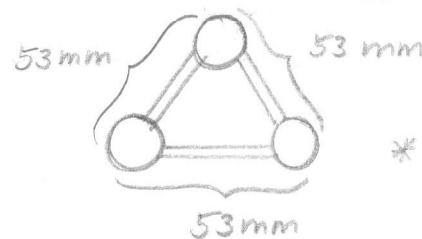


Geomag Triangle



$$\begin{aligned}\text{length of base: } & 124.90m - 74.24m \\ & = 50.66m\end{aligned}$$

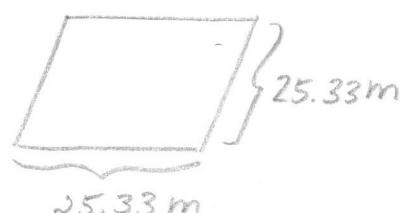
$$= \frac{50.66}{2} = 25.33m$$



* 1 rod + 2 spheres
= length

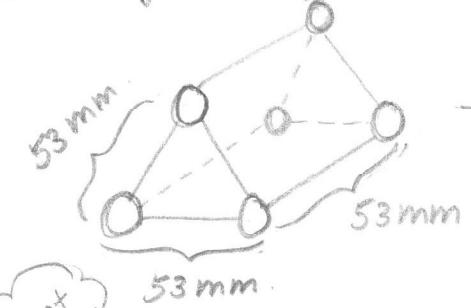
$$\begin{aligned}\text{length} &= 27.00mm + 2(13mm) \\ &= 27mm + 26mm \\ &= 53mm \\ &= 0.053m\end{aligned}$$

Base of Eiffel Tower (leg).

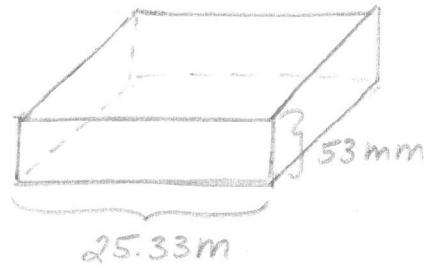


①

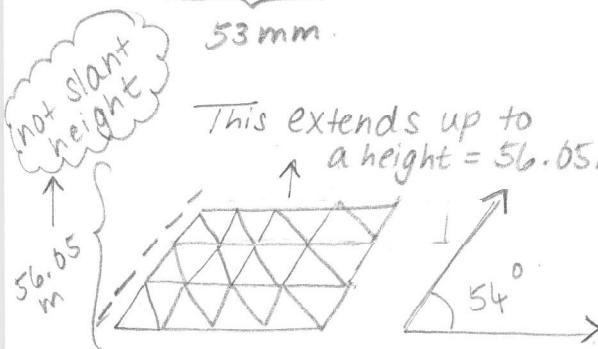
Geomag Triangular Prism



Use this shape to fill in the cube



↳ Base of leg on Eiffel Tower.



- fill in box with triangular prisms.
- Stack up the cuboid on top of each other and account for the 54° angle.
- height until the first platform = 56.05 m.
- stack cuboids until it reaches a height of 56.05 m.

Volume of Box:

$$\text{Volume} = l \times w \times h$$

$$= 25.33 \text{ m} (25.33 \text{ m}) (53 \text{ mm})$$

$$= 25.33 \text{ m} (25.33 \text{ m}) (0.053 \text{ m})$$

$$= 641.6089 \text{ m} (0.053 \text{ m})$$

$$= 34.005 \text{ m}^3$$

* Assumption: I have used the triangular prism as my base structure because of further research, I found that this structure is rigid and doesn't break easily.

Volume of Triangular Prism:

$$\text{Volume} = (\text{base} \times \text{height} \times \text{length}) / 2$$

$$\text{base} = 53 \text{ mm} \text{ or } 0.053 \text{ m}$$

$$\text{height} = 0.053 \text{ m}$$

$$\text{length} = 0.053 \text{ m}$$

$$\text{Volume} = [(0.053 \text{ m})(0.053 \text{ m})(0.053 \text{ m})] / 2$$

$$= 1.488 \times 10^{-4} \text{ m}^3$$

2

$$= 7.4438 \times 10^{-5} \text{ m}^3$$

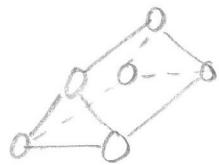
How many prisms fit into the box (cuboid)?

$$\frac{\text{Volume of Box}}{\text{Volume of Triangular Prism}} = \frac{34.005 \text{ m}^3}{(7.4438 \times 10^{-5} \text{ m}^3)}$$

$$= 456,823 \text{ prisms}$$

Number of Geomags needed to fill one cuboid (box):

First layer:



$$+ 5 \text{ rods \& } 2 \text{ balls} \Rightarrow$$

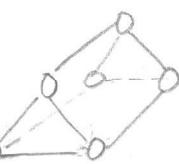


* accounts for overlap
of rods and balls
going left to right

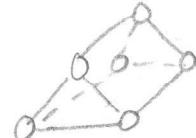
- This approach will work when we stack the cuboid boxes on top of each other to form multiple layers.

* This approach does not account for overlap of geomags front to back

1st prism has 6 rods and 3 balls
so we take away 1 prism and calculate for remaining prisms



$$+ 6 \text{ rods \& } 3 \text{ balls} \Rightarrow$$



FRONT TO BACK!

* There is overlap of geomags *

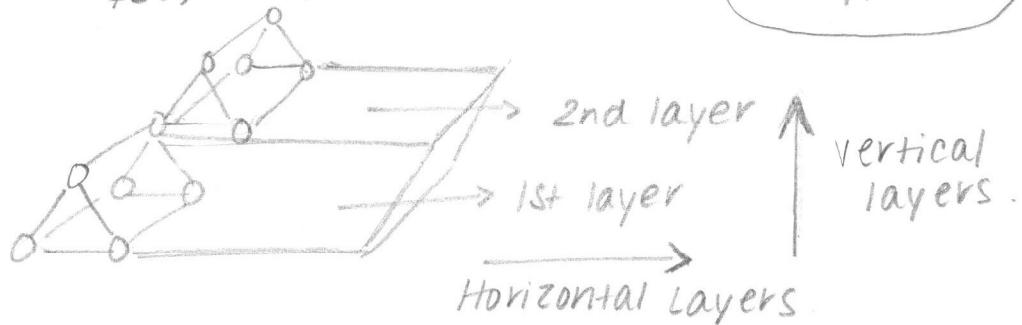
$$\underline{456,822 \text{ prisms (5 rods)}} + 9 = \underline{2284119 \text{ rods}}$$

$$\underline{456,822 \text{ prisms (2 balls)}} + 6 = \underline{913650 \text{ balls}}$$

From second layer onwards: $456,822 \text{ prisms (5 rods)} + 5 = 2284115 \text{ rods}$

$$456,822 \text{ prisms (2 balls)} + 2 = 913646 \text{ balls}$$

Diagram:



Calculating slant height:

- height until second platform = 115.73 meters

- create a right triangle and use SOH CAH TOA to determine slant height



$\sin = \frac{\text{opposite}}{\text{hypotenuse}}$

$$\sin 54^\circ = \frac{115.73 \text{ m}}{X}$$

$$\text{Solve for } X: \frac{\sin 54^\circ}{\sin 54^\circ} (X) = \frac{115.73 \text{ m}}{\sin 54^\circ}$$

$$X = 207.1085 \text{ meters}$$

Determine number of layers (until second platform):

height until 2nd platform = 115.73 meters

each cube is 0.053 meters tall

$$\therefore \text{number of layers} = \frac{115.73 \text{ meters}}{0.053 \text{ meters}}$$
$$= 2183.58 \text{ layers}$$
$$\approx 2184 \text{ layers}$$

Total number of geomags per layer:

Total # of layers = 2184

1st layer \Rightarrow 2284119 rods and 913650 balls

2nd layer onwards: 2183 layers (2284115 rods)

$$= 4986223045 \text{ rods}$$

- AND -

$$2183 \text{ layers } (913646 \text{ balls})$$
$$= 1994489218 \text{ balls}$$

Total # of Geomags \Rightarrow 2284119 rods + 4986223045 rods
= 4988507164 rods.

- AND -

$$913650 \text{ balls} + 1994489218 \text{ balls}$$
$$= 1995402868 \text{ balls.}$$

* NOTE THAT THIS IS ONLY FOR ONE LAYER *

- The Eiffel tower has 4 legs so multiply number of balls and rods by 4 legs

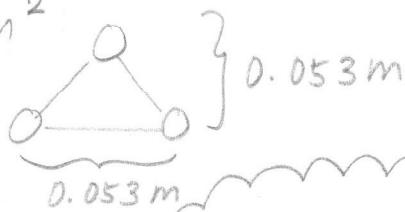
$$\text{TOTAL} \Rightarrow 4988507164 \text{ rods } (4) = 1954028660 \text{ rods}$$
$$1995402868 \text{ balls } (4) = 7981611472 \text{ balls.}$$

Calculating number of geomags needed for each platform:

* I am assuming that the platforms are flat

$$\text{Area of 1st platform} = 4,010 \text{ m}^2$$

Area of geomag triangle



$$\text{Area} = \frac{1}{2}bh$$

$$= \frac{1}{2}(0.053 \text{ m})(0.053 \text{ m})$$

$$= 1.4 \times 10^{-3} \text{ meters}^2$$

* We will be constructing the platform by using triangle shaped geomags to fill up the area of the platform (I am accounting for overlap if geomags)

Total # of triangles for platform ①:

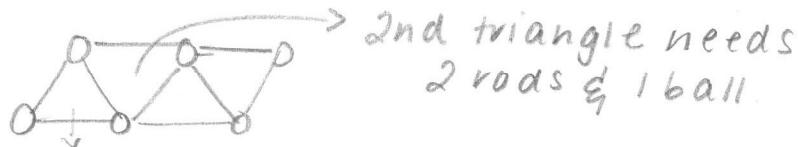
$$4010 \text{ m}^2 \div 1.4 \times 10^{-3} = 2855108.58 \text{ triangles}$$

does not include 1st triangle $\leftarrow \approx 2855109 \text{ triangles}$

Total # of geomags: $2855108 \text{ triangles (2 rods)} + 3$ \rightarrow accounts for the 3 rods in the first triangle and overlap of geomags from left to right
= 5710219 rods

$$2855108 \text{ triangles (1 ball)} + 3 \leftarrow \text{same logic but for sphere balls.}$$
$$= \boxed{2855111 \text{ balls}}$$

Diagram:



Total number of geomags needed for platform ②:

$$\text{Area of 2nd platform} = 1360 \text{ m}^2$$

$$\text{Total # of triangles} = \frac{1360 \text{ m}^2}{1.4 \times 10^{-3} \text{ m}^2}$$

$$= 971428.5714 \text{ triangles} \approx 971429 \text{ triangles}$$

* similar calculation to platform ①

Total # of Geomags: $971428 \text{ triangles (2 rods)} + 3 = \boxed{1942859 \text{ rods}}$

$$971428 \text{ triangles (1 ball)} + 3 = \boxed{971431 \text{ balls}}$$

Total number of geomags needed for platform ③:

Area of 3rd platform = 264.31 m^2

$$\text{Total # of triangles} = \frac{264.31 \text{ m}^2}{1.4 \times 10^{-3} \text{ m}^2} = 188792.8571 \text{ triangles}$$

$\approx 188793 \text{ triangles}$

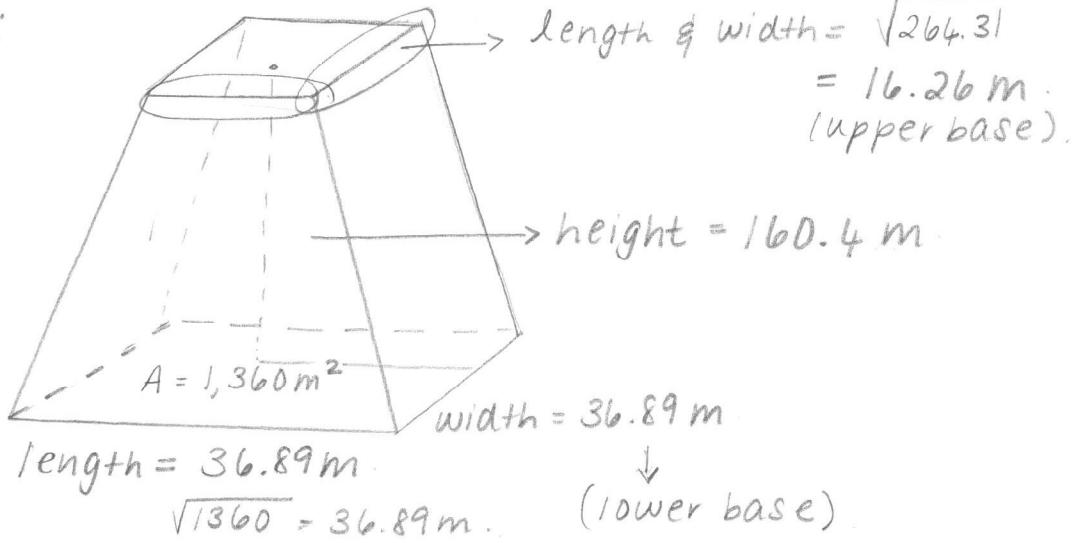
Total # of Geomags: $188792 \text{ triangles (2 rods)} + 3 = 377587 \text{ rods}$

$188792 \text{ triangles (1 ball)} + 3 = 188795 \text{ balls}$

Truncated Square Pyramid.

- the truncated square pyramid extends above the 2nd platform

Diagram:



Calculate volume:

$$V = \frac{1}{3}(a^2 + ab + b^2)(h)$$

a = length of lower base

b = length of upper base

h = height

$$\text{Volume} = \frac{1}{3}[(36.89)^2 + (36.89)(16.26) + (16.26)^2](160.4)$$

$$= \frac{1}{3}(1360.8721 + 599.8314 + 264.3876)(160.4)$$

$$= \frac{1}{3}(2225.091)(160.4)$$

$$= 118968.1988 \text{ m}^3$$

* I will be using triangular prisms to construct the truncated square pyramid

* Volume of truncated pyramid divided by volume of prisms

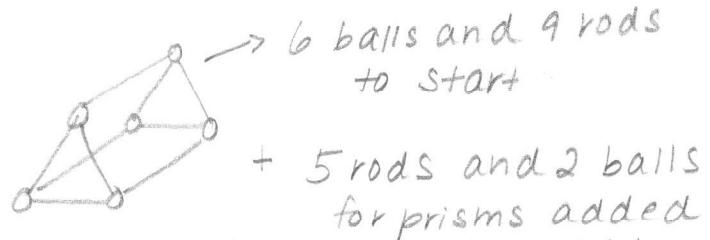
Total number of triangular prisms needed to construct truncated square pyramid:

$$118968.1988 \text{ m}^3 \rightarrow \text{volume of truncated square pyramid}$$

$$7.4438 \times 10^{-5} \text{ m}^3 \rightarrow \text{volume of triangular prism.}$$

$$= 1598218636 \text{ prisms.}$$

First layer of truncated pyramid \Rightarrow



From second layer onwards \Rightarrow adding 5 rods and 2 balls left to right

* 1st prism on 2nd layer will only need 5 rods and 2 balls

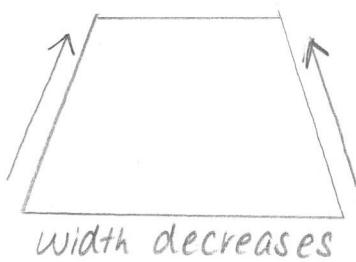
Total # of Geomags needed for truncated square pyramid:

$$1598218635 \text{ prisms (5 rods)} + 9 = 7991093184 \text{ rods}$$

$$1598218635 \text{ prisms (2 balls)} + 6 = 3196437276 \text{ balls}$$

- This method will have a lot of overlap because the truncated square pyramid doesn't have a constant breadth (width decreases as you go up \rightarrow hence why we cannot use stack approach!)

Diagram:



Tip of Eiffel Tower

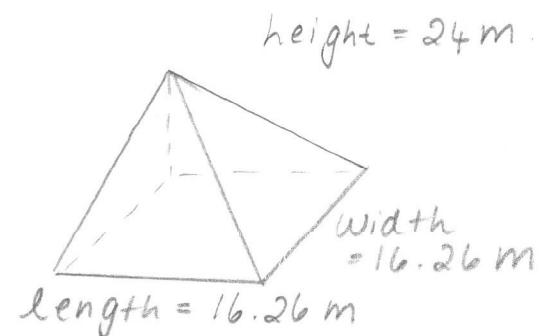
- I am assuming it is a square pyramid

$$\text{Volume} = \frac{1}{3} B h, \quad B = \text{base area}$$

$$\text{Base area} = l \times w$$

$$= 16.26 \text{ m} (16.26 \text{ m})$$

$$= 264.3876 \text{ m}^2$$



$$\text{Volume} = \frac{1}{3} (264.38) (24)$$

$$V = 2115.1008 \text{ m}^3$$

Number of triangular prisms enclosed in square pyramid:

$$\frac{\text{Volume of square pyramid}}{\text{Volume of triangular prism}} = \frac{2115.1008 \text{ m}^3}{7.4438 \times 10^{-5} \text{ m}^3}$$
$$= 28414261.53 \text{ prisms}$$
$$\approx 28414262 \text{ prisms.}$$

Total # of Geomags in square pyramid:

$$28414261 \text{ prisms (5 rods)} + 9 = 142071314 \text{ rods}$$
$$28414261 \text{ prisms (2 balls)} + 6 = 56828528 \text{ balls}$$

* Not accounting for overlap of prisms

WE ARE NOT CALCULATING THE # OF GEOMAGS NEEDED FOR ANTENNA!

Total # of Geomags needed to construct Eiffel Tower:

of rods for 4 legs : 1954028660 rods

rods of platform ① : 5710219 rods

platform ② : 1942859 rods

platform ③ : 377587 rods +

rods in truncated square pyramid : 7991093184 rods

rods in square, pyramid :

10095223820 rods

of Balls — 7981611472 balls → balls for 4 legs

2855111 balls → balls of platform ①

971431 balls → platform ②

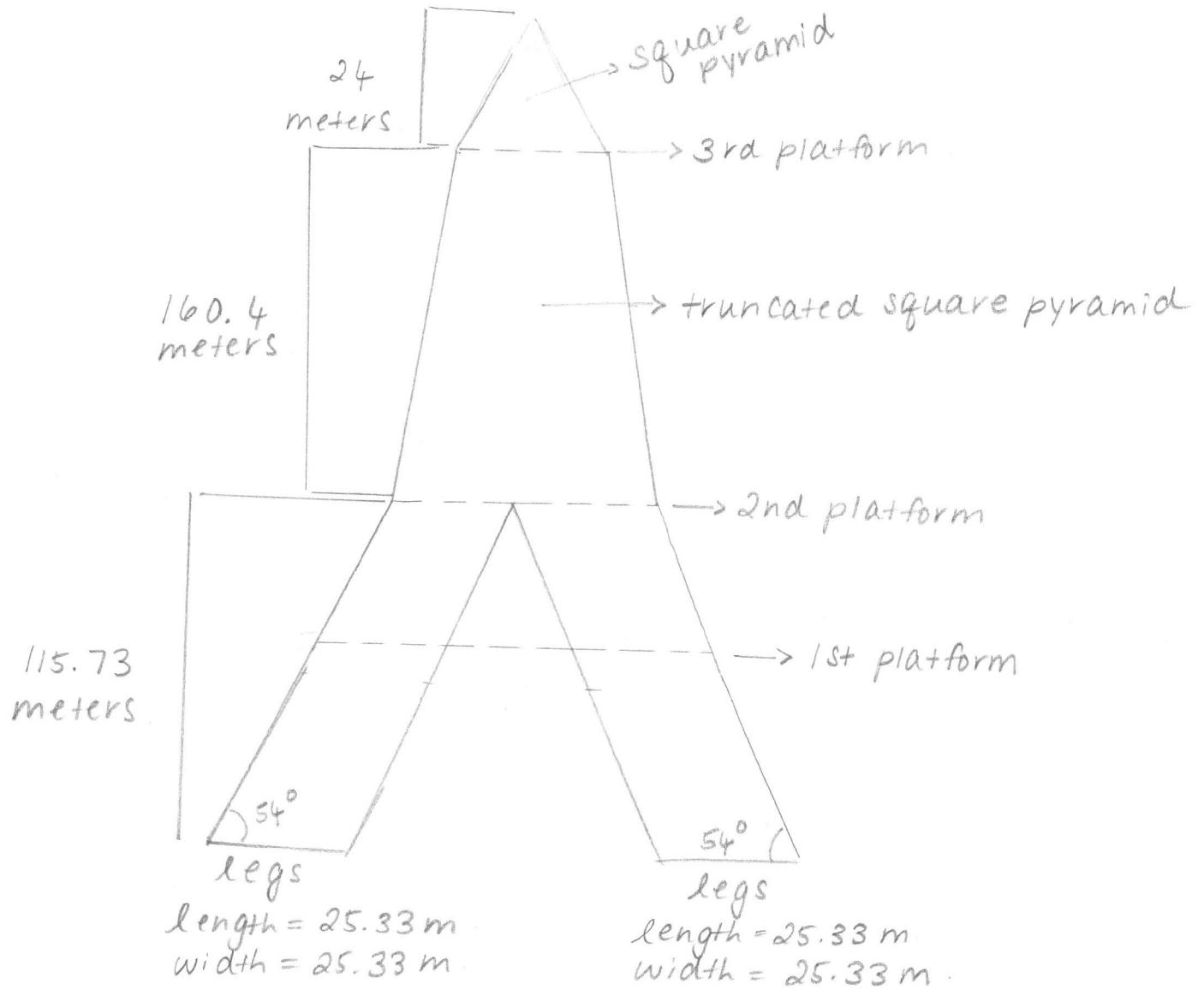
188795 balls + → platform ③

3196437276 balls → truncated square pyramid

56828528 balls → square pyramid.

11238892610 balls

Diagram of Eiffel Tower based on what we calculated and assume it will look like using Geomags



NOTE: I know this doesn't really resemble the Eiffel tower, but I personally think it's better... Am I right!? !!