# Can we play frisbee on the top of our building?

## 1. Summary

At MSA, we have a rooftop, however, this rooftop does not seem to be as safe as it could be. In this article, we are going to discuss the issue of whether learners and teachers can play frisbee on the rooftop or not. We have conducted some research into the opinions or perceptions of learners and teachers and also based on a series of facts about the rooftop to prove it.

## 2. Introduction

### 2.1. Interview

Before starting the calculations for this topic, we interviewed several learners and guardians in the community, all of whom represent different interests and have different perspectives.

Maria Pan: There is no suitable ground in the park, the campus is also easy to smash to public property/people, do not go to the rooftop to go where the weather, the school should raise the fence, throw out high throwing objects is very dangerous.

Antis Wang: An enclosed roof should be added to the rooftop.

Chengjun Song：The rooftop is to give students exercise, as long as we pay attention to a little will be fine.

Zekuan Huang: It may be necessary to increase the height of the guardrail to prevent the Frisbee from falling, and secondly, it may be necessary to wrap the top part of the window to avoid touching it.

Billy Wang：Frisbee is easy to fall from the roof, and the roof is not completely flat. The construction is not over yet

Qizheng Wang: My opinion is that it's not very good for playing games, but it could probably be used to practice passing the Frisbee. Mainly because there are a lot of windows for ventilation, which affects the running, but also brings safety risks, so the competitive game is not very suitable for the rooftop. If we stand still to pass the frisbee to each other will be less affected by the obstacles, the feasibility of some high.

Zale Yang: The main consideration should be afraid of flying discs outside the rooftop to hit others, as well as the ground is not flat for fear of falling If the rooftop floor is repaired, in the case of ensuring safety can still try.

## 2.2 **Problem Interpretation**

Our goal is to determine if playing frisbee on a rooftop is a good idea or not. Because this is a big question and could be affected by lots of sides and factors, so we decided to do a few sides to narrow the scope of research, to make the research result as accurate as possible.

1. Will the Frisbee fly out of the guardrail and cause injury?
2. Will the Frisbee break other things on the rooftop, such as glass?
3. Will the students fall because of the uneven ground on the roof, thus causing injuries?

The second and third parts are not so much related to what we have learned (trigonometric functions). So we chose the first part as the problem we want to solve. Then, we list some of the problems that we need to solve related to the first part.

1. For objective facts, how tall is the building? How high are the railings protecting the rooftop?
2. For making and calibration of measuring tools, how to make a protractor and measure the data?
3. For frisbee relating issues, quality of frisbee, power, usage scenarios (training or competition)? How to influence the flight path of the frisbee?
4. Give our first three parts to different audiences to collect their feedback and make our content part better.

The first two-part about measuring the height of a building are mainly because we need to use trigonometry to do the measuring and calculating to match the learning in class. On the downwards, we will use some methods which we searched on the internet and some of the academic papers because we don’t have the time and space and equipment to research everything and writing algorithm.

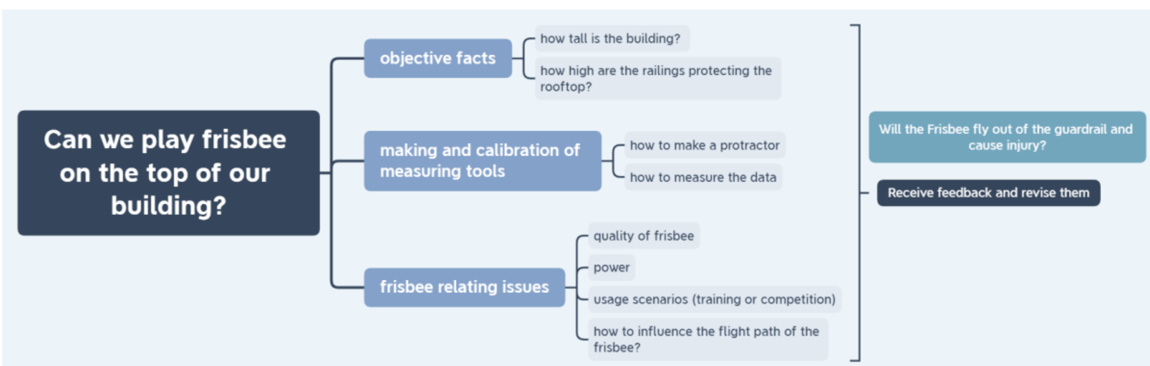



Figure 1 Our train of thought to the question

# 3. Assumptions

It is necessary to make a few preliminary assumptions so that a clear and logical solution to be outlined

(1) Assumption 1: Length and angle measuring

We only use our actual measured data for investigation and the existing actual data for reference (the actual height of the building and railings, etc.).

Justification: Because our equipment is not very accurate, and some of the data we made an estimated value to let the calculation be friendly, so all the length and angle we estimated it to one digit. And it still has a deviation from the actual data.

(2) Assumption 2: Applicable people and method

We only consider the people who have played and know how to play frisbee. Which they all have no desire of throwing a hammer, and no one will hold a tournament on the rooftop.

Justification: The setting for no beginners is because they don't know how to throw the frisbee and some of the postures are not correct, so it might be a risk for the frisbee don't move with horizontal movement. Besides, there're more uncertainty event will happen on them.

Hammer is a way to throw frisbee above your head and their trajectory is more like a parabola. It will easily cross the railings so it cannot be added to the research area.

For matches, there will be a frisbee kick-off and will throw a long distances disc and the height will exceed the height of the fences. So it also couldn't be added into the research area

(3) Assumption 3: Setting consensus

Assume that when we throwing the frisbee, all the disc will exactly be flying straight to the front.

Justification: The disc could go up and down, but if turns to leave or right in the air, which is another variable for us to concern about and if we do, we need to modify its trajectory and will cost a lot of time and stress. Furthermore, we don't have that kind of equipment to do this.

(4) Assumption 4: environment and weather setting

We suppose that the weather should be only a sunny day and with nothing but a clear sky and sunshine. And the ground facilities of the school roof have finished their construction.

Justification: For the convenience of focus on the main topic, we need these assumptions to make more unstable variables be exact and will be least effective to the testing result.

(5) Assumption 5: about frisbee. When throwing in the same angle of attack, the more the velocity reaches, the higher the frisbee will be.

When we were doing our testing, we found that the higher the frisbee gets, the more velocity of frisbee will get. But we couldn't find any of the literature to explain this.

Justification: maybe there's a physical principle that could explain by "at the same distance, because the speed is fast and the time of gravity action is short, the displacement on the vertical distance is not easy to drop, so it is easier to fly out." But since we couldn't test if this is a theorem or just a coincidence. So, we just simply use it as a theorem.

# 4. **Way to Conclusion**

To measure all the angles, we believe the only thing we need is just a semicircle with a center on it. Because it's less than 1.5m, so we could just use a regular ruler to measure the length of the side of a right triangle and use trigonometry like sine, cosine, and tangent to solve the angle. Using the tangent theorem to solve out the elevation and depression angle. And use this formula to solve the height of the building and the fences

$$H = h + \frac{h}{tan\alpha_2} \times tan\alpha_1 \quad ①$$

Here $\alpha_2$ means the angle of depression and $\alpha_1$ means the angle of elevation. $h$ means the height of your vision. $H$ means the object that you need to measure, which right here, means the height of the building.

We use a chair to represent $h$ as 105.8cm② and a compass made by ourselves. Eyesight looking to the bottom of the building and makes the base of the compass aim on the bottom line of the building. Do our best to make it stable in order to control the measurement error. We use a ruler to aim at the top of the building and let the other one draw one tangent point on the paper card compass. And another point for the fences. Then we tied a heavy object with a rope, facing it to the ground. A hand sticking it on the 90-degree point on the arc. Make the center point of the compass move no further, and draw a point on the base of the compass crossing with the line. To know the angle of depression. (For angle of depression, we didn't actually calculate out this one, we just use ruler to measure out the distance from the perpendicular line and the center of our compass, divided by the radius to measure out the tangent value of the angle of depression. So down below, $tan\alpha_2$ is actually a ratio.)

Then we use two angles of the height of the building and it's added with fences height to finally get the height of the fences and height of the building. Which are 4.17 meters for fences and 11.56 meters for the building.

---

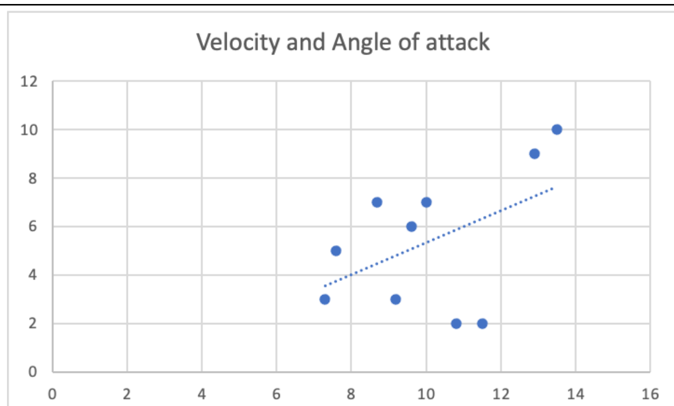
① Here, $\alpha_1 and\ \alpha_2$ both are angles; $\alpha_1 = 59°$ $tan\alpha_2 = 0.12$

② This number has already calculated and modified measurement errors

Next is about the frisbee itself. Because we don't have the time and space and equipment to test how the frisbee flew. We use an app called tracker to trace the trajectory of the frisbee. And did a few times throw, here's what we've got.

As we couldn't track down the whole path of particle for the frisbee. We found an academic article[3] about frisbee's physics. Which they were discussing the trajectory of frisbee and a physical model. In that article, the testing speed of its frisbee is 14m/s as a beginning speed. After a few rounds of the test, we found out that the average throwing speed and practice speed in the short and medium-range of the beginning speed of frisbee will be no more than 14m/s.

| Practice throws for small angles and large velocities which are larger than 7m/s. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Velocity (Ordinate) | 7.3m/s | 8.7m/s | 7.6m/s | 9.2m/s | 11.5m/s | 9.6m/s | 10.8m/s | 12.9m/s | 10m/s | 13.5m/s |
| Angle of attack (Abscissa) | 3 | 7 | 5 | 3 | 2 | 6 | 2 | 9 | 7 | 10 |




From this graph, there's a few outliers point in it. But even if there are two outliers, they still don't exceed the maximum value in the graph of our reference. So it won't be a trouble of our conclusion.

Figure 2 our testing result

So that we took some references from it. Here's the testing result and trajectory of frisbee with releasing angle from 5-10 degree and with a velocity of 14m/s which came from the academic article.

For this part of our angle measuring, we used a APP called Concept Sketchpad(概念画板). Use the rotation angle which the APP has, we drew a horizontal line and a line which coincide with the disc in the picture from one frame of our testing video (let me call it disc line). And then rotate the disc line to match with the horizontal line to see how much degree it rotates.

Original graphs from the essay are placed down below

[3] Morrison, V. R. "The physics of frisbees." Electronic Journal of Classical Mechanics and Relativity 8.48 (2005).

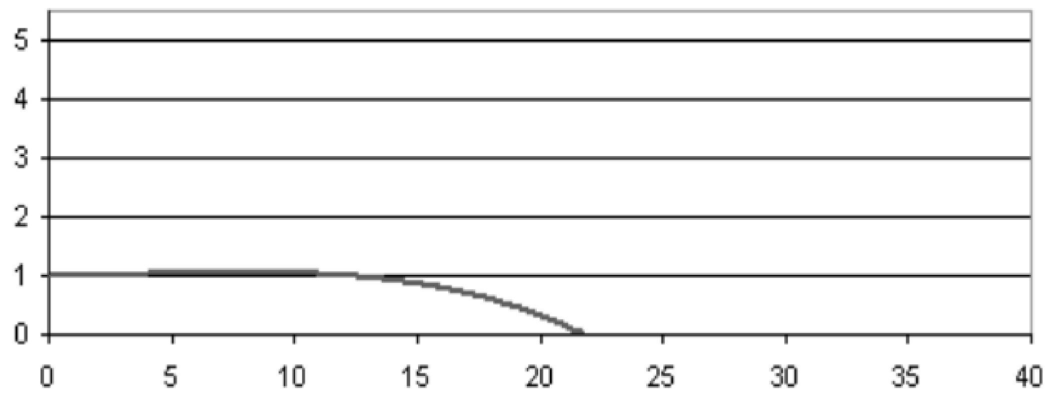



Figure 3

Plot of height(m) versus distance(m) for a Frisbee with initial velocity 14m/s and angle of attack 5°.

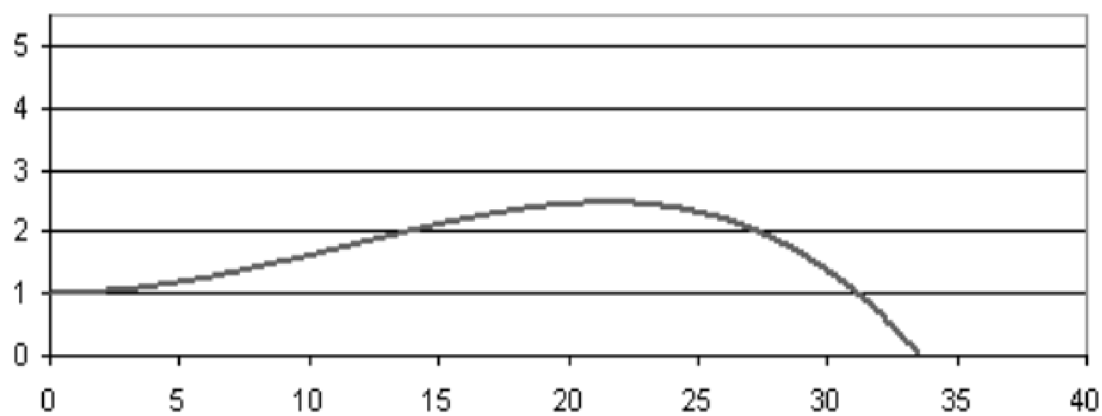



Figure 4

Plot of height(m) versus distance(m) for a Frisbee with initial velocity14m/s and angle of attack 7.5°.

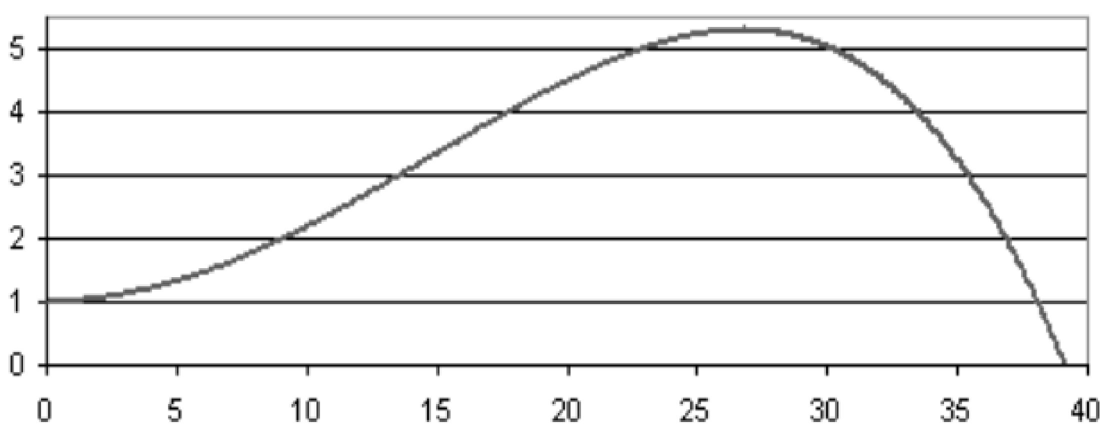
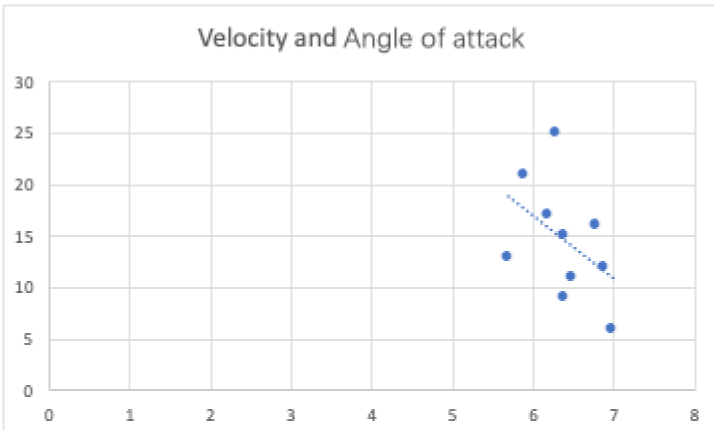



Figure 5

Plot of height(m) versus distance(m) for a Frisbee with initial velocity 14m/s and angle of attack 10°

From the graphs above, we can see that if the angle attack with 10 degrees and with the velocity of 14m/s, after the disc fly out for about 17 meters away could fly over the fences. But when we testing randomly throwing of the disc and one time of "kick-off" throw, the data shows that with a large angle attack of practice throw, the velocity won't be larger than 7m/s.

| Practice throws for big angles and small velocities which are less than or equal to7m/s. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Velocity (Ordinate) | 6.2m/s | 6.5m/s | 5.7m/s | 6.8m/s | 6.9m/s | 6.6m/s | 5.9m/s | 6.4m/s | 6.3m/s | 7.0m/s |
| Angle of attack (Abscissa) | 17 | 11 | 13 | 16 | 12 | 15 | 21 | 9 | 25 | 6 |




In this graph, there's an outlier in out testing result which is the point (6.3,25) This won't be a worry for out conclusion because of its velocity is lower than 7m/s so the height of the disc won't be very heigh.

Figure 6

So for practicing throwing the disc, the fences are high enough to prevent the disc from flying off the roof. With the "kick-off" throw, in which the angle attack is 15degree and the velocity is about 17m/s, and that will be a rick of the disc flying over the fences. So, it's fair enough to not holding games on the roof.

# 5. **Conclusion**

According to the movement of the frisbee with an initial velocity of 14m/s, when the frisbee with an angle of attack for 10° and 20-32 m away from the fences, the disc could fly out of the building. But according to assumption 2, the people who know how to play frisbee and has no desire to throw a hammer will not throw a disc like that. As you can see in figure 4 the frisbee first goes up and then goes down. This kind of long distant passing is called sweepstakes and we don't often do that. Also, according to assumption 2, we can pass the disc for short-range only, and the people who might know how to throw a long distant disc like that, when they do, will be a potential risk for crossing over the fences. To sum up, we can know that when the angle between 5°-7.5°, the height of the disc will be less than 3 meters. But the height of the fences is 4.17

meters. To sum up, I think students can play Frisbee on the top of our building, but at the same time, some rules need to be made, under which the frisbee will not fly out. The rules read:

1. No matches are allowed on the roof
2. Do not throw hammer
3. You can practice game tactics but not practice sweepstakes
4. Make sure the Angle is not too big
5. If you must practice a large Angle, pay attention to keep a distance from the fences

# 6. Strengths and Weaknesses

Strengths：

(1): Most of the people in our school will be happy with this conclusion.

(2): The model we use comes from a study that put a sensor at the button of the frisbee

Weaknesses：

(1): We used a lot of assumptions that we can't control.

(2): In assumption 2 although they can't start a match where they can practice it.

(3): The frisbee may still go off the fences.

# 7. Feedback

Anitis Wang: Overall there is nothing wrong with it. Graphs and analyses are available and relatively well written.

Qizheng Wang: Did a very good job! I can not find any mistakes inside and the report is good.

# References

[1]Hubbard, M., and S. A. Hummel. "Simulation of Frisbee flight." 5th Conference on Mathematics and Computers in Sport, University of Technology, Sydney. 2000.

[2]Lorenz, Ralph D. "Flight and attitude dynamics measurements of an instrumented Frisbee." Measurement Science and Technology 16.3 (2005): 738.

[3]Morrison, V. R. "The physics of frisbees." Electronic Journal of Classical Mechanics and Relativity 8.48 (2005).

[4]Baumback, Kathleen. "The aerodynamics of frisbee flight." Undergraduate Journal of Mathematical Modeling: One+ Two 3.1 (2010): 31.

[5]Weizman, Yehuda, Adin Ming Tan, and Franz Konstantin Fuss. "Measurement of Flight Dynamics of a Frisbee Using a Triaxial MEMS Gyroscope." Multidisciplinary Digital Publishing Institute Proceedings. Vol. 49. No. 1. 2020.

[6]张晓娟. "飞盘漩涡稳定性的理论和实验研究." 云南大学学报 (自然科学版) 2019 年 03 (2019): 503-507.