

# 2019 年臺灣國際科學展覽會 優勝作品專輯

作品編號 160029

參展科別 物理與天文學

作品名稱 Effect of Air Resonance by Wind Speed  
Difference on Falling fruit

得獎獎項 二等獎

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## 作者照片



**Abstract** This study completes an air vibration equation expressed wind speed slope and wind speed. First, preliminary experiments identified air vibrations when wind speed differences occurred over distance. Several air fans were connected in series and the rotational speed of the air fan was adjusted to vary the wind speed with distance. At this time, only certain pendulum oscillates during a particular wind speed slope. It was expected that the pendulum would shake because the frequency of the air due to the slope of the wind speed was equal to the natural frequency of the pendulum. In addition, relatively short pendulum swings in large wind speed slope, long pendulum swings in short wind speed slope. After calculating the natural frequency of the seasonal growth of fruit using the physical factors model, we experiment how resonant frequency was related with cone length, angular width, wind speed, velocity and secondary derivative. the actual experiment analyzed the natural frequency of the fruit and resonance from the air vibration as the linear function of the wind speed, velocity, and secondary derivative.

The experiment determined that the pendulum of a specified number of frequencies resonated with a particular wind speed pattern. It is judged that the vibration of air is related to first derivative of wind speed depending on speed and distance. However, it is very difficult to express the flow of nonlinear fluids as a function of simple function, particularly the effects of air vibrations caused by wind speed second derivative, which appeared to be associated with forces. This is a task that needs to be solved through further research.

**Key Words :** Air Vibration Model, Natural Frequency, Resonance, Velocity difference, Wind Speed Inclination

## 1. A general outline

### ☐ A research object

○ The study was conducted in a way that further deepened previous research and gave proof of our hypothesis. A previous experiment was conducted to install a windbreak forest, and a method to reduce the falling fruit by using only the placement of fruit trees. As a result, the goose gets less air resistance because it flies in a triangular shape when it happens to fly. This led to the question of whether the triangular arrangement would reduce the wind velocity, which was compared with what was currently being used in farming households, and which deployment had less pleasure and effect. In addition, we tried to model physical pendulum as a first experiment to build relationship between natural frequency and wind of apples, and to propose a air vibration model to confirm that our second experiments are identical to the frequencies found above. This is a theoretical hypothesis, and experiment 1 was tested, but experiment 2 was not conducted to prove it. Based on the content of Experiment 2, the study tries to learn more about the study of resonance and air vibration, which is the content of Experiment 1 and Experiment 2. So we designed resonance experiments and tested how resonant frequencies relate to speed.

## ☐ Scope of study

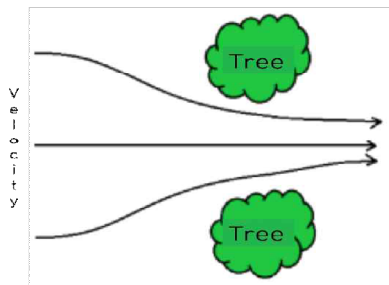
- Measurement of the shaking of a physical pendulum by wind speed
- A Study on the resonance of a physical pendulum by wind speed difference
- Identification of air vibration phenomena expressed as nth derived function of wind speed and wind speed

## 2. Research content

### ☐ Theoretical background and prior study

- Continuous equations and tree shapes

The multiplication of cross sectional area in a fluid and the velocity of the right across the cross section is constant, so wind speeds up in the furrow between trees and trees. Large differences in wind speed produce turbulence. Turbulence is the main cause of falling fruit. Therefore, less turbulence can be used to harvest many crops such as apples. It also decided to find the placement of trees based on adequate ventilation, and the size of the flow and the number of trees that can keep the frequency of vibrations constant.



[Fig. 1] An increase in wind speed by the blast of wind

$$\text{Entrance area} \times \text{Entrance velocity} = \text{Exit area} \times \text{Exit velocity}$$

$$\therefore \text{Exit velocity} = \frac{\text{Entrance area}}{\text{Exit area}} \cdot \text{Entrance velocity}$$

formula 1. Continuous equation

### ☐ Select subject of research

#### ☐ The solution of a problem

○ First, we investigated the maximum wind speed and direction of typhoon that come to our country. Second, wind speed and wind speed difference were considered the biggest factors affecting the falling fruit. Third, we tried to model physical pendulum

and relationship with natural frequency of apples, and fruit became also considered as size changes over time. Fourth, we propose an air vibration model and want to check if it is the same as the frequency obtained above.

15.7	118	15	15	13.3	18.3	10	9.3	16	10	7.3	26.1	5.8
22.5	9.5	9.2	16.8	12.8	14	9.9	8.1	5.7	13	7	14.5	11

Table 1. Wind speed of typhoons from 1990 to 2004

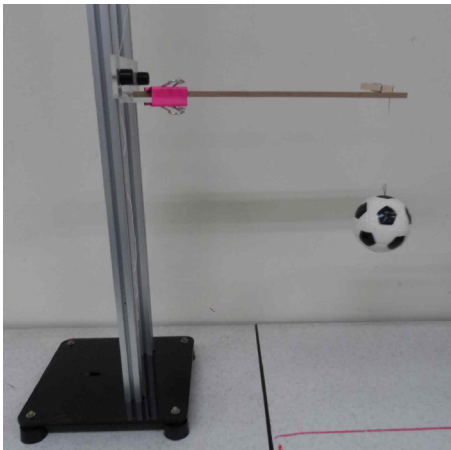
#### □ A method of study

##### ○ Experiment 1 : Qualitative check of air vibration model

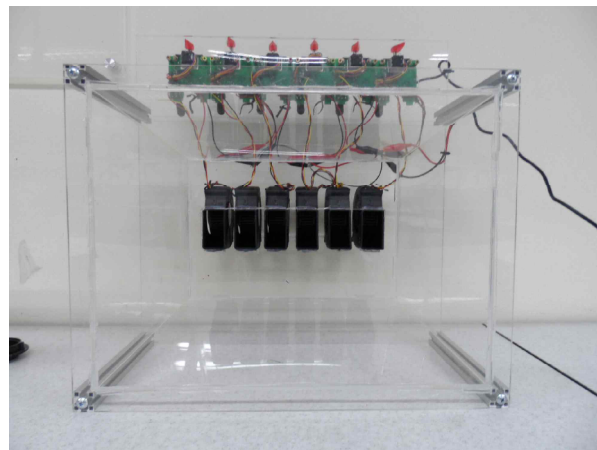
An experiment that checks the vibration of air when wind speed difference occurs.

##### ○ Experiment 2 : Resonance due to wind speed difference

The following experiment confirmed that a cone with a certain length of cone pendulum causes resonance when given an inclination of speed. The experimental apparatus was constructed as follows.

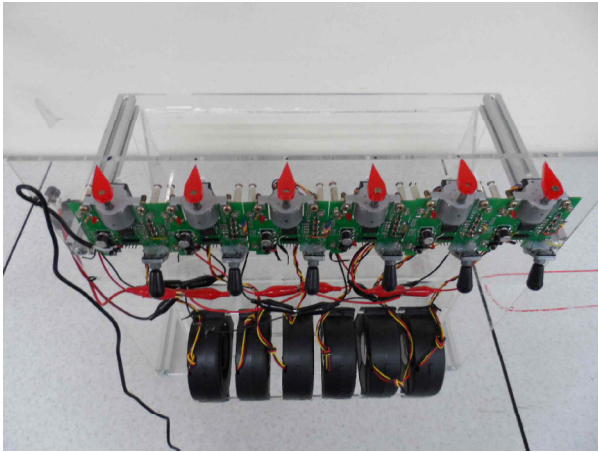


[Fig. 2] A pendulum model

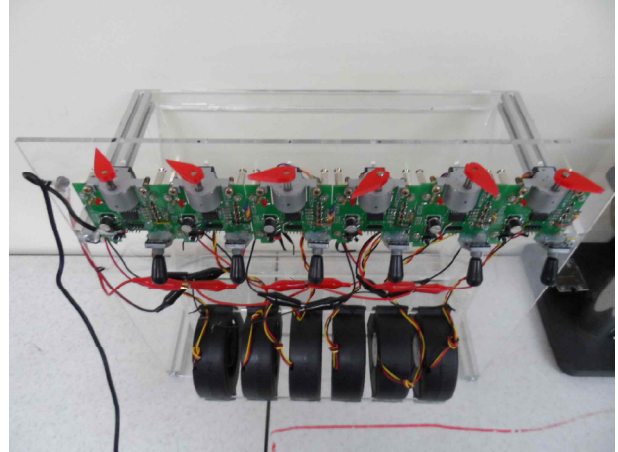


[Fig. 3] Wind Speed Inclination Device

The length of the pendulum was adjusted with its upper tongs. The wind strength is indicated using the device below to provide a more visual feel of the wind velocity when using [Fig. 3] wind speed inductive device.



[Fig. 4] No inclination of wind speed



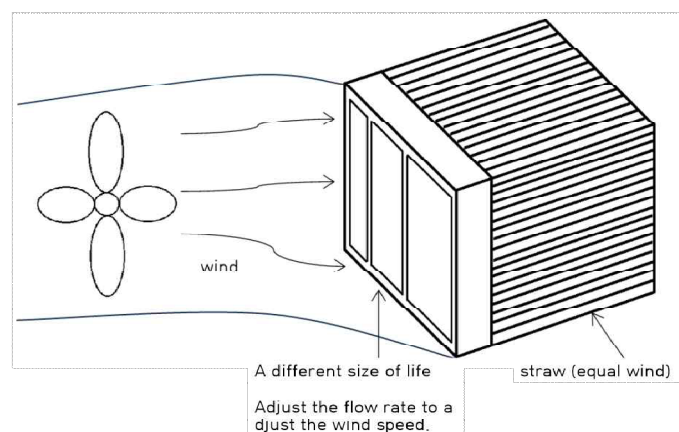
[Fig. 5] In case of wind speed gradient

[Fig. 4] is the picture when there is no wind speed difference, i.e. when the wind speed is all the same and the initial value of the device. [Fig. 5] is a picture of the device when it produces a wind speed difference. Wind speed is stronger as it goes counterclockwise based on [Fig. 4]. If you look at [Fig. 5] the wind speed increases from left to right.

## ☐ Research Activities and Processes

### ☐ Experiment 1 : Qualitative check of air vibration model

#### <Experiment method>



[Fig. 6] Experiment to check the gradient of speed

When the wind is blowing, the size of the hole changes to primarily control the amount of wind. And a straw was installed to maintain the wind velocity through

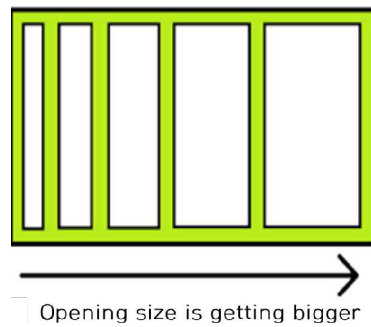
the hole so that other winds could be constant to the target without being affected. Winds with different wind speeds were observed to produce gradients at a constant speed to vibrate Styrofoam balls. The next picture is a model made from a straw.



[Fig. 7] A lateral figure



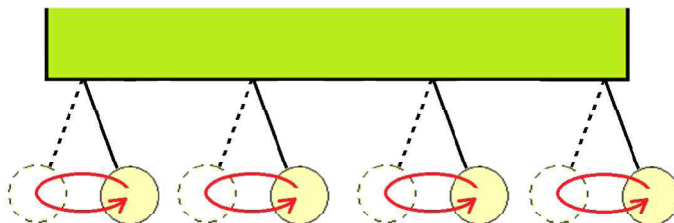
[Fig. 8] A frontal view



[Fig. 9] Board

Install the same plate as [Fig. 9] to build a wind speed gradient. The size of the gradient of the wind speed was to be adjusted by the speed of the wind at the wind speed.

### <Experiment result>



[Fig. 10] Vibration at certain speeds

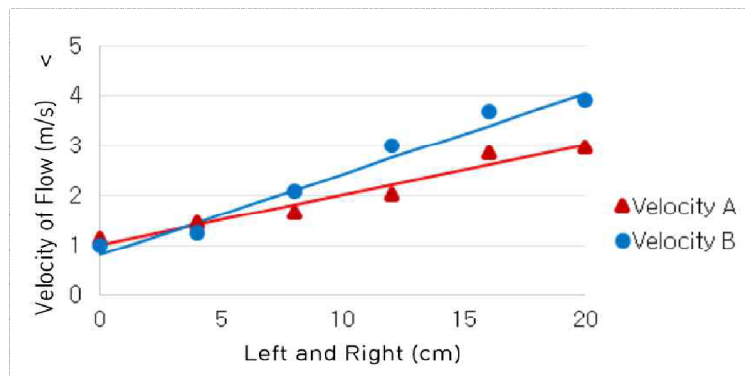


[Fig. 11] An actual photograph

As the wind grew stronger and stronger, we could see all the pendulum resonating together in a particular wind. This confirmed that the slope of the speed was the same as the frequency of the pendulum, and the resonance associated with the frequency of the pendulum would also have to do with the slope of this speed.

N	$l(\text{cm})$	$f_{\text{physical pendulum}}$	Velocity A	Velocity B
1	10	1.57	$\Delta$	x
2	9	1.66	$\circ$	x
3	8	1.76	$\Delta$	$\Delta$
4	7	1.88	x	$\circ$
5	6	2.02	x	$\Delta$

Table 2. Number of vibrations along the length of a pendulum

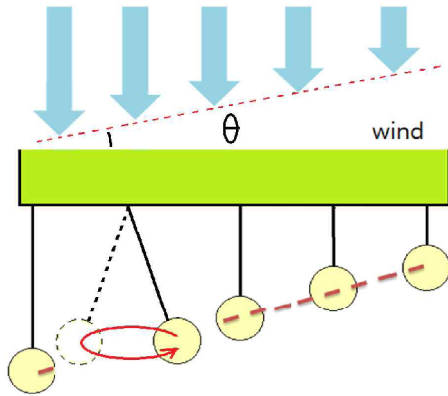


Graph 1. Measurement Results

When I measured the wind speed differently, the gradient of the speed was different as shown in the graph above. And based on the theoretical values, the number of vibrations in the physical pendulum increased as the length of the pendulum got shorter. And Table 2. above shows the degree of shaking of the pendulum in  $\circ$ ,  $\Delta$  and X.

At a speed of A with a small gradient of wind speed, experimentally showed that vibration was greatest at a low frequency of No. 2 pendulum.



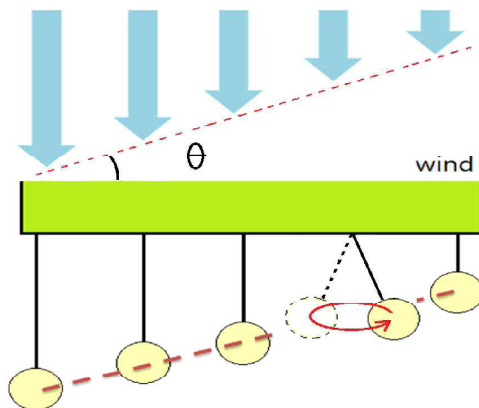


[Fig. 12] When the wind speed difference is small



[Fig. 13] An actual photograph

On the other hand, at speed B, which has a large gradient of wind speed, experimentally showed that vibration was greatest at No. 4 pendulum with a relatively large frequency.



[Fig. 14] When the wind speed difference is big



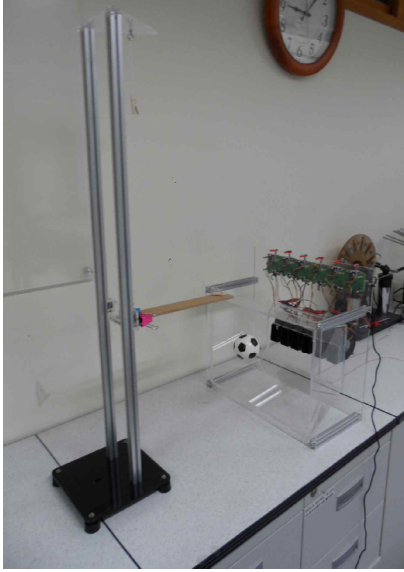
[Fig. 15] An actual photograph

It may be experimentally inaccurate, Based on the air vibration model, the relationship between the slope and the frequency of velocity was determined experimentally using the number of vibrations through the physical particles.

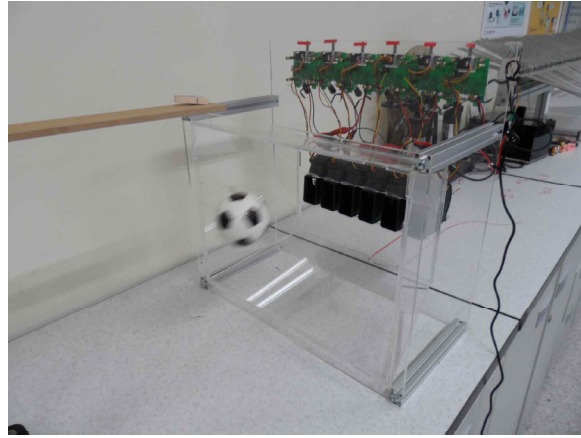
## ○ Experiment 2 : Resonance due to wind speed difference

### <Experiment method>

The equipment was placed and tested as shown in the following figure.



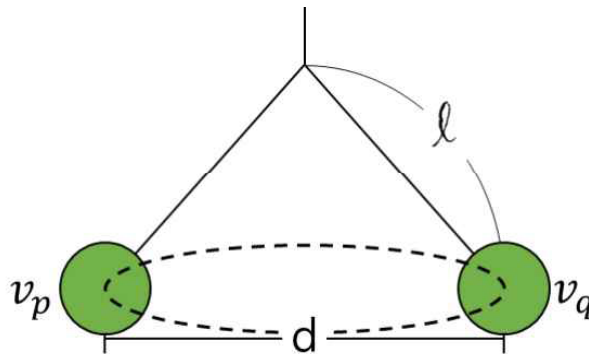
[Fig. 16] Experiment Photo 1



[Fig. 17] Experiment Photo 2

Wind speed inclination device formed an inclination to wind speed. The length of the pendulum has been adjusted to confirm that the pendulum of a certain length resonates in a cone shape.

When this model continued to run in the cone shape, according to the inclination of the wind speed, the pendulum is resonance to measure the difference in wind speed( $\Delta v$ ),  $v_p$ ,  $v_q$ , length of the pendulum  $l$ , diameter  $d$  of the cone, and frequency were measured.



[Fig. 17] Conical pendulum model

### <The result of an experiment>

Aerodynamics is a nonlinear problem and is very difficult to interpret. We tried to interpret the vibration of air as a function of wind speed and wind difference and

confirm it through pendulum. Wind speed inclination device made the gradient of the speed and then found that the pendulum of a certain length shook at a specific rate change with a frequency. Tests show that the pendulum is completely resonating, but sometimes the vibration is attenuated and then increased and repeated. It said that the frequency does not match completely and that beating phenomenon is caused by a very small  $\Delta f$ .

The measured values are shown as a table when resonance occurs.

$l$ (the length of a pendulum)	$d$ (the diameter of a pendulum)	cycle	$v$	$\Delta$	$\Delta v/d$	$(average\ v) \times \Delta$	$l/d$ (Angular)	$(average\ v) \times \Delta v/d$
12 cm	20 cm	0.764 s	$m/s$	1.6 $m/s$	0.08	4.48	0.6	0.224
11 cm	25 cm	0.714 s	$m/s$	1.7 $m/s$	0.68	4.25	0.44	0.17
9 cm	20 cm	0.672 s	$m/s$	0.9 $m/s$	0.045	3.25	0.45	0.1575

Table 2. Measurement when resonant phenomena occur

### 3. Research Results and Implications

#### ☐ The results of a study

○ The air vibration model showed that the pendulum was short in length in case of large wind speed gradient, and in case of small wind speed gradient, the pendulum with long pendulum length and small vibration frequency were resonance. The relationship between the slope of speed and the frequency of vibration is identified by qualitative analysis. This is related to a past experience of falling fruit.

In the final experiment, the length of the pendulum did not affect the period of the pendulum. It was also confirmed that the greater the cycle, the greater the angular width.

#### ☐ Implication point

○ Experiment 1 found resonant phenomena of the pendulum at certain speeds. The resonant frequency was shown to be proportional to the function of speed and speed over distance. When expressed in a formula, this is as shown in  $f_r \propto v \cdot \frac{dv}{dx}$ . The resonant frequency was considered to be related to the speed, the speed of the distance, and the range speed, which is considered to be proportional to  $\alpha$ -square speed,  $\beta$ -square of the derivative function,  $\gamma$ -square of the second derivative function. We have described this as  $f(v, v', v'') \propto v^\alpha \cdot \left(\frac{dv}{dx}\right)^\beta \cdot \left(\frac{d^2v}{dx^2}\right)^\gamma$ . The fact that the resonant frequency is related to a function of the velocity of the distance was demonstrated in Experiment 1, and the fact that a function of speed and distance affects both was identified in Experiment 2. This shows that  $\alpha$  and  $\beta$  are formed when 1 are, and further studies will find out the exact formulas of  $\alpha, \beta, \gamma$ .

#### 4. Promotion and Application plan

- ☐ the publication of a dissertation
- Presentation of research on campus project and presentation of research results at science festival
- Notify the fall-prevention effect of fruit through SNS
- Exchange of R&D with the Agricultural Technology Center
- A Study on the Effect of Air Resonance on Wind Speed Pattern and the Linear Relationship between Falling and Fruit

#### 5. Reference

Jinpyung Lee, Sang-Joon Lee, "Wind engineering study on sheltering effect of a windbreak forest" 11, PP10-14, 2011

Sung-hoon Jung, "Developing Growth Model of Windbreak Forest on the west coast of Korea and Analyzing Effects of Windbreak Facilities based on Wind Tunnel Test", February, 2013

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The falling fruit due to the Strong Wind make a serious damage. The authors create a model to reduce this damage by changed the shape of the field the effect of air resonance. This is a good application of a physics model to benefit the farmers.