23rd IYPT Problem : Paper Anemometer

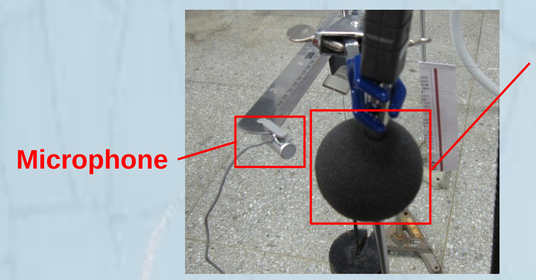
Jong-Ching Wu, Jun-Yu Chu
National Changhua Normal University, Concordia Middle School

Abstract

When thin strips of paper are placed in an air flow, a noise may be heard. Investigate how the velocity of the air flow can be deduced from this noise.

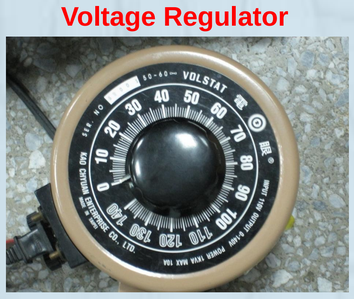
Two properties of the noise may be investigated: sound intensity and sound frequency. By analyzing the noise with a microphone, we observed that the frequency of the noise is randomly distributed. However, we found out that the sound intensity measured increases with the flow velocity. A research done by E. Y. Yudin verified that the intensity of sounds created by vortices is proportional to the sixth power of the flow velocity in low wind speeds. Using this relationship, we can fit a formula to our results and successfully predict the wind velocity with a good precision.

Experimental Setup



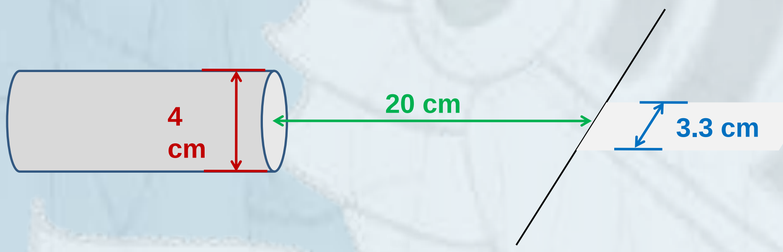
(a) Newspaper Strips
(b) Wind Blower
(c) Microphone
(d) Oscilloscope Program
(e) Decibel Meter
(f) Voltage Regulator

Voltage Regulator



Wind Blower

■Dimensions of the Experiment:



Wind velocity is adjusted by using the voltage regulator.

Theory

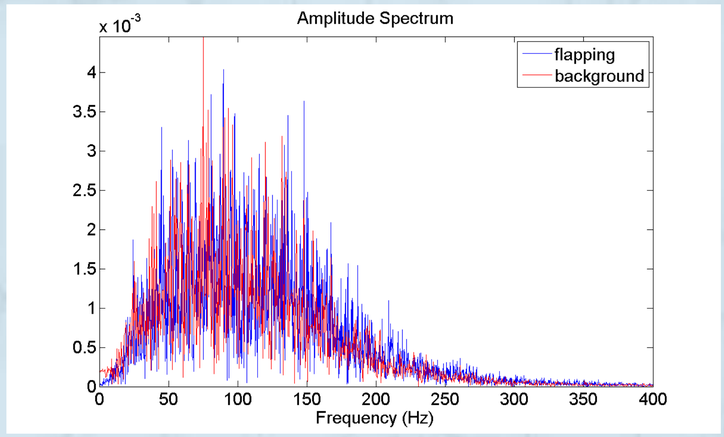
■Yudin's Supposition:

Vortices are created when the air flow interacts with the paper strip. The noise created by the vortices has an intensity that is proportional to the sixth power of the flow velocity. This is proven to be correct under flow velocities of low Mach numbers.

$$v^6 \propto I$$

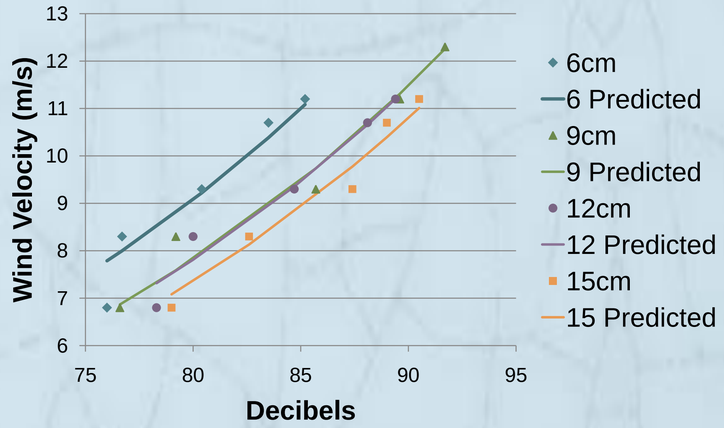
Result

■Frequency Analysis

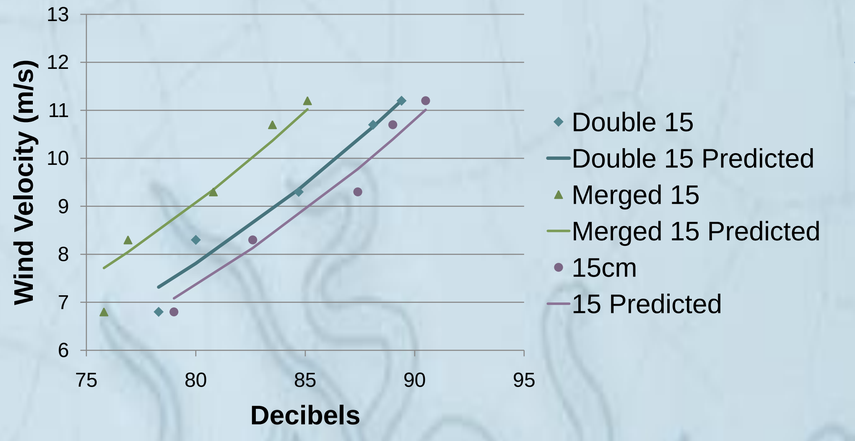


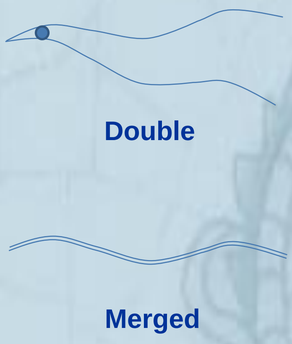
According to the data, there is no specific frequency in the noise made by the paper strip.

■Amplitude Analysis



With the sixth-power relationship, Decibel-Velocity curves can be fit to the data points. The ratio coefficient, however, varies with different experimental conditions.





The sixth-power relationship is applicable under all conditions in the experimental range.

15cm Single Paper				
dB	V (m/s)	Predicted (m/s)	Deviation (m/s)	Deviation %
79.00	6.80	7.08	-0.28	4.14%
82.60	8.30	8.13	0.17	2.04%
87.40	9.30	9.78	-0.48	5.11%
89.00	10.70	10.39	0.31	2.86%
90.50	11.20	11.01	0.19	1.69%
			AVG	3.17%

Example of a prediction of wind velocity.

The prediction proved to be reasonably accurate.

Conclusion

Constructing the experimental setup with all dimensions fixed and calibrating it with different known wind velocities, we can create an accurate anemometer based on Yudin's supposition.

Reference

[1] E. Y. Yudin, Zh. Tekhn. Fiz. 14, 561 (1945)