PURDUE UNIVERSITY

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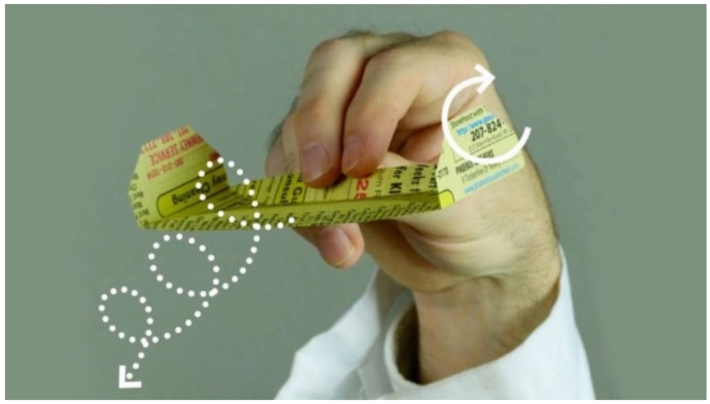
STEM Lesson Plan: Flying Tumblewing



Approaching problem-solving through scientific inquiry is one of the goals of a lesson plan in which student teams construct flying tumblewings from paper and then compete to see which one travels the furthest distance.

"I wanted an easy-to-implement activity for teachers which could be done on virtually any budget at any location," said Scott Bartholomew, assistant professor of Engineering-Technology Teacher Education at Purdue University and creator of the lesson plan. "As students practice controlling and manipulating variables as well as recording and interpreting outcomes, they should begin to understand a scientific approach to problem-solving."

The lesson plan involves teams of two or three students constructing tumblewings from several pieces of phone book paper and tape. Each team uses practices of science and engineering to explore the best possible specifications to maximize their tumblewing's flight. They test and evaluate their designs, record design decisions in tables provided in the lesson plan, and make arguments as to which combination of variables will produce longer flights.

The lesson, which can be completed in one to two hours, was originally devised for middle school students (ages 12-14), but Bartholomew noted it works for other ages. "I have tried it with students from fourth grade up through the university level and have found success at all levels," he said.

Bartholomew recommends using this lesson plan in the larger context of learning about the principles of flight, such as Bernoulli's principle and Newton's laws, and the basic rules of force, mass, energy, work, and power. He also noted that it could fit into any STEM class.

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Create a flying Tumblewing

Dr. Scott Bartholomew, Purdue University

INTRODUCTION

A **tumblewing** is a type of glider or kite which rotates about an axis and exhibits **lift** as the tumblewing alternates between **flying** and **stalling (free fall)**. One common example of a tumblewing is confetti which "tumbles" as it falls. The alternating flying and stalling of the confetti creates the visual appeal.

ACTIVITY OBJECTIVES

1. Students will understand and be able to explain the **forces of flight** as they relate to the tumblewing.
2. Students will work together in a collaborative setting to experiment with tumblewing modifications (**practices of science and engineering**).
3. Students will design, construct, test, modify, and re-test their tumblewing (**engineering design process**).

HOW DOES A TUMBLEWING WORK?

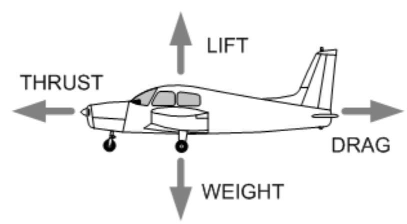


Figure 1 - LangleyFlyingSchool.com. http://www.langleyflyingschool.com/Pages/Private%20Pilot%20Program.html

To understand how a tumblewing works we need to first understand flight. There are four forces that act on an object in flight: **weight/gravity**, **lift**, **thrust**, and **drag**. In order for an object to stay airborne the **lift** must overcome the **weight/gravity** and the **thrust** must overcome the **drag**. If you simply drop your tumblewing you will notice that it spins about its axis and slowly descends – in this case the **drag** and the **weight/gravity** will slowly bring the tumblewing down. If you walk behind the tumblewing with a piece of cardboard you push air in front of the cardboard (this upward draft in air is called **ridge lift**) which acts as an upward **lifting** force as well as a forward **thrust** force. Balancing these forces allows the tumblewing to maintain steady flight.

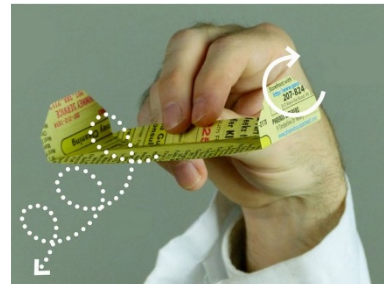
KEY TERMS

- **Forces of flight**
  - **Weight/gravity** – the force pulling an object towards the Earth's surface
  - **Thrust** – the force pushing an object forward (i.e. created by the airplane engine)
  - **Lift** – a force which pushes an object upward (in a tumblewing this is **ridge lift**)
  - **Drag** – the force that acts opposite to the direction of motion - caused by friction and differences in air pressure.
- **Flying** – achieved when weight/gravity and drag are not greater than lift and thrust
- **Stalling** – when an aircraft does not have enough lift to continue in flight
- **Engineering Design Process** – a series of steps used while solving a problem

Technology & Engineering Design Challenge

Construct a Tumblewing that travels the furthest distance

I. Challenge



In this engineering design challenge, you will work in small teams (2-3 students) and be given the resources needed to design and build tumblewings. A bonus will be given for the tumblewing that travels the furthest distance without touching the ground

II. Criteria and Constraints

- The tumblewing must be constructed from only phonebook paper and tape
- The tumblewing must be constructed from no more than 1 single sheet of phone book paper
- The tumblewing must be powered by nothing other than the air deflected from one piece of cardboard (12" x 12").
- Team members may "drop" the tumblewing to start flight but may not touch the tumblewing following the initial drop
- Team members **may** modify the tumblewing shape in anyway
- The Internet can be used to search for ideas.

III. Resources

- 5 pieces of phone book paper
- Tape
- Scissors
- Tumblewing templates

IV. Evaluation

- 10 Points: Built and flies more than 30' (9.1 meters)
- 9 Points: Built and flies less than 20' (6.1 meters)
- 5 Points: Not completed or launched - effort shown.
- 0 Points: No effort shown.

Practices of Science & Engineering

Testing, Evaluating, Analyzing, Interpreting, and Acting on evidence

Introduction

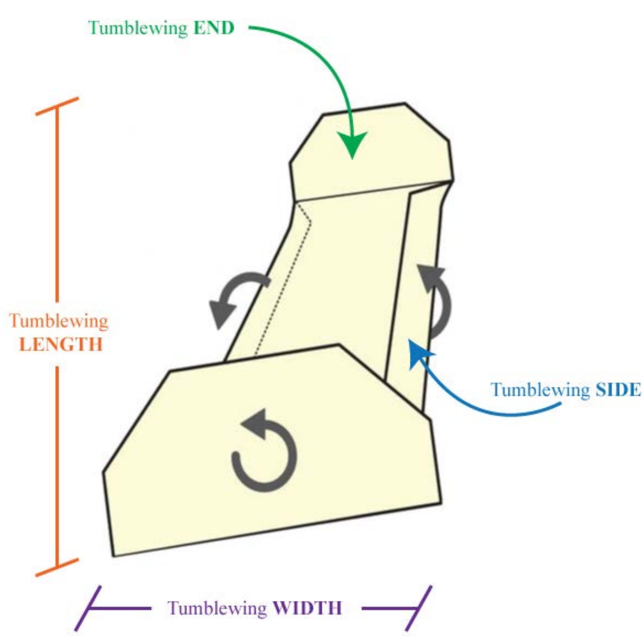
In the “Engineering Design Challenge” part of this activity, your team was challenged to construct a tumblewing that would travel at least 30,’ with a bonus for traveling the furthest. One step of the engineering design process involves **“Testing and Evaluating.”** As part of the testing and evaluating process you will record several pieces of data that will lead you to another practices of Science and Engineering: **analyzing and interpreting data**.

Following your testing you should work as a group to analyze the data, interpret the results, and then decide on a course of action for constructing the best possible tumblewing. This decision to purse a particular course of action is another principle of Science and Engineering: **making an argument from evidence.**

Procedures

In this activity, you will use the practices of science and engineering to explore the best possible specifications to maximize flight for your tumblewing. Use the tables below to **test and evaluate** different combinations of bend in your tumblewing. After you are done with the **testing and evaluating** use the space below to **make an argument** as to which combination of variables will produce the longest flight for your tumblewing.

- *Test only one variable (change) at a time. For example, choose a set fold measurement for the ends and test the side folds at different measurements. Then choose the best fold for the sides and test the ends at different measurements. By holding all variables except for one constant we can better see the impact of a single change in the tumblewing!*



Example

Trial #	Length of tumblewing	Width of tumblewing	Fold length (ends)	Fold length (sides)	Results (how far did it go)
Ex. 1	*5”*	*2”*	*¼”*	*1/8”*	*12’*
Ex. 2	*5”*	*2”*	*½”*	*1/8”*	*10’*
Ex. 3	*5”*	*2”*	*1”*	*1/8”*	*9’’*

Test different **fold lengths (sides)** here

Trial #	Length of tumblewing	Width of tumblewing	Fold length (ends)	**Fold length (sides)**	Results (how far did it go)
1					
2	[redacted]	[redacted]	[redacted]		
3	[redacted]	[redacted]	[redacted]		
4	[redacted]	[redacted]	[redacted]		

Test different **fold lengths (ends)** here

Trial #	Length of tumblewing	Width of tumblewing	**Fold length (ends)**	Fold length (sides)	Results (how far did it go)
1					
2	[redacted]	[redacted]		[redacted]	
3	[redacted]	[redacted]		[redacted]	
4	[redacted]	[redacted]		[redacted]	

Test different overall tumblewing **widths** here

Trial #	Length of tumblewing	**Width of tumblewing**	Fold length (ends)	Fold length (sides)	Results (how far did it go)
1					
2	[redacted]		[redacted]	[redacted]	
3	[redacted]		[redacted]	[redacted]	
4	[redacted]		[redacted]	[redacted]	

Test different overall tumblewing **lengths** here

Trial #	**Length of tumblewing**	Width of tumblewing	Fold length (ends)	Fold length (sides)	Results (how far did it go)
1					
2		[redacted]	[redacted]	[redacted]	
3		[redacted]	[redacted]	[redacted]	
4		[redacted]	[redacted]	[redacted]	

Make an argument based on evidence

Now that you have conducted several **tests** and **recorded your results** it's time to **analyze the data**. Look through your trials for each variable and as a team decide what combination of measurements will produce the longest flight for your tumblewing. Record your argument below (make sure to base your argument off of the evidence [results] you collected).

Example: Based on our experiments we have chosen to make our final tumblewing 4" long and 2" wide with side folds on ½" and end folds of 1". When using these measurements we recorded the longest flights with our tumblewing.

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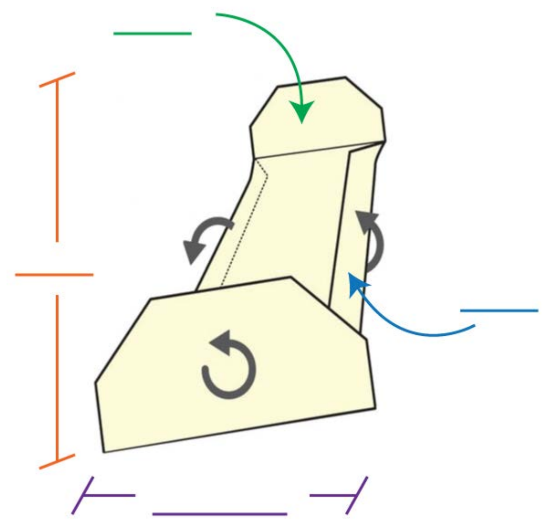
FINAL MEASUREMENTS:

Fill in the final measurements you chose for your tumblewing in the blanks below:



Principles of Flight

Describe each principle of flight as it relates to your tumblewing. What provides each force and how do they interact with each other?

Lift:

____

____

Weight/Gravity:

____

____

Thrust: ______________________________________

____

Drag: ____