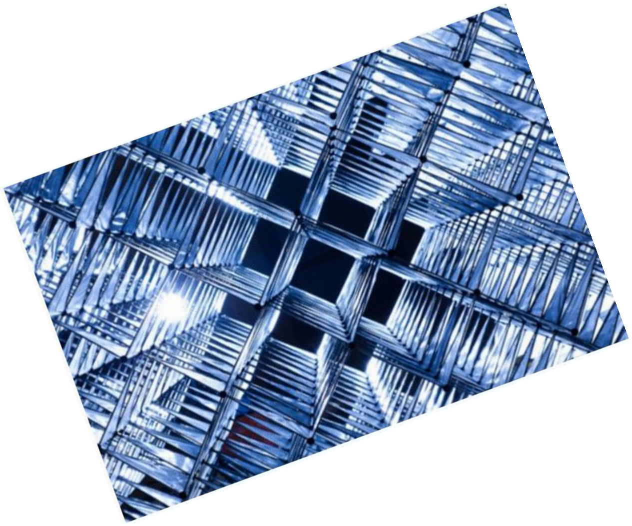
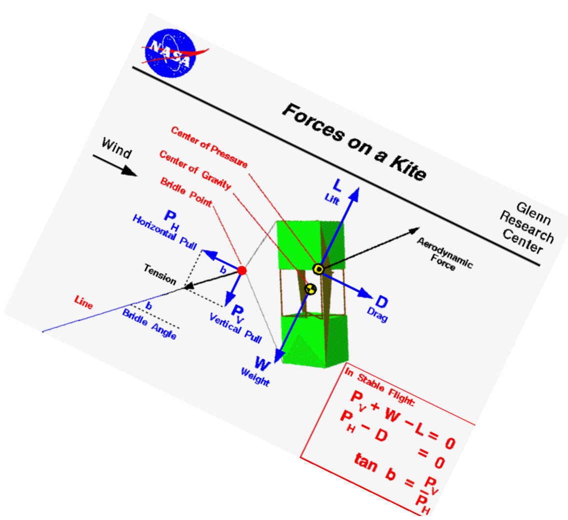


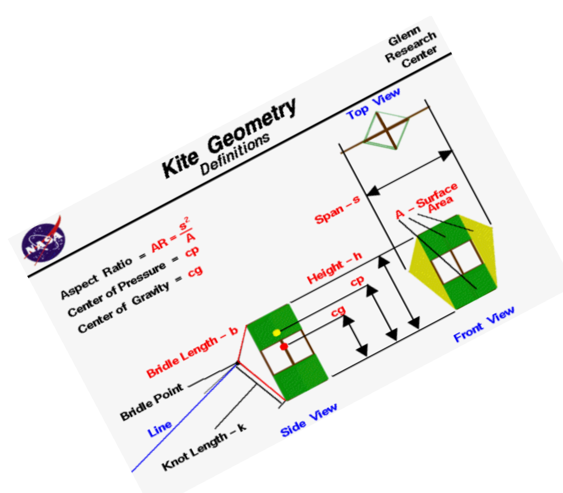
Up, Up, & Away – Redesigning the Impossibilites

Adrienne Murchland

Grade Levels 7th – 8th

August 6,2015





II. Introduction

1. ***Rationale***

Three Curriculum and Instruction models were used in this unit; Visual Thinking Strategy, Socratic Seminar, and Creative Problem Solving. These models helps students develop skills to conduct investigations and develop creative and innovative solutions.

The Visual Thinking Strategy used in this unit is valuable in growing students' cognitive skills by encouraging students to express mathematical meaning visually. Looking at an unfamiliar object causes the student to form new concept ideas and to revisit original concept ideas. The spatial layout of the three-dimensional object helps to explain how the objects' form functions in a realistic way.

Socratic Seminar used in this unit is valuable in enhancing skills such as collaboration, listening and speaking skills, and critical reasoning skills. Students were able to question and examine mathematics and science principles while analyzing, interpreting, and listening to various points of view. Studying the diagrams and visualizing how different forces (lift, drag, center of gravity, pull, etc.) relate to the dimensions, angles, and various shapes of the cells provided students the opportunity to understand a complex text. The seminar laid the foundation for using content and concept knowledge in creatively solving problems during the engineering process of designing kites.

Creative Problem Solving used in this unit is valuable in developing skills for achieving exceptional performance in fixing a discrepancy between a current situation and a desired outcome. Students overcame the need to quickly solve a problem or give up easily as they followed the engineering process and applied geometry concepts to their solutions. These models encompass many dimensions and features of differentiation.

2. **Differentiation for Gifted Learners**

Differentiation is the key to growing gifted learners. This unit benefited gifted learners through advanced and unique content which challenged them to use geometric terms and formulas in a complex in-depth way. As they viewed an optical illusion painting and read a complex article on kite structure they were able to explain how and why the volume, surface area, and dimensions of the materials influence the effects of motion by later creating a product (kite) and its design. They went beyond reciting vocabulary, memorizing formulas, and solving math problems from a book to creating and solving their own mathematical problems as they related those problems to the engineering process. This helps to further develop their problem solving skills and apply mathematics in a real world scenario.

Two students were then able to accelerate their geometry knowledge by applying the Pythagorean theorem and the Triangle Inequality theorem as they created their three-dimensional kites. These students used these theorems along with the structure or surface area of the materials to explain how the form of the kite influenced the function of the kite through forces of motion on the kite, such as horizontal and vertical pull, weight, lift, tension, bridle angles, the center of gravity, and drag.

Establishing a learning environment that allowed complex discussions through Visual Thinking Strategies and Socratic Seminar and creative problem solving through the engineering process provided students' different ways to acquire the content, make sense of their ideas and apply their knowledge. Students became frustrated with some of their setbacks, yet as they followed the redesign process excitement and engagement were magnified as they began to understand the issue and then develop and apply creative problem solving skills to give them a sense of pride and accomplishment.

III. Goals and Outcomes

<u>Content</u> Goal and Outcome

Goal 1: To solve real-world mathematical problems involving three-dimensional objects and develop an understanding of the effects of motion on those objects.

Students will know…

A. How and why the volume, surface area, and dimensions of the materials influence the effects of motion by testing the design of their kites
B. The reasoning of the mathematical formulas used to create their objects (kites), by describing why and how the calculations work in design while using correct terminology
C. The effects of motion on different forms of three-dimensional objects (kites) by comparing and contrasting the design processes of their different styled kites

<u>Process</u> Goal and Outcome

Goal 2: To develop problem solving skills with application to mathematics and engineering

Students will be able to…

A. Create calculations and explain the effects of those calculations on their designs.
B. Apply creative problem solving skills to understand mathematical formulas.
C. Analyze and infer how mathematical relationships influence form/function of flying objects
D. Apply, analyze, and evaluate the engineering process by creating flying objects through design, construction, testing, and redesign.

<u>Concept</u> Goal and Outcome

Goal 3: To understand the concept of form influences function

Students will understand…

A. The appropriate geometric terms to use when creating, describing, and testing structures to fulfill its purpose or function.
B. The knowledge learned about geometric form and function from using the engineering process can transfer to understanding other forms, functions, and processes in other disciplines
C. That various three-dimensional shapes of design impact the intended purpose or function of the design.

IV. Assessment Plan

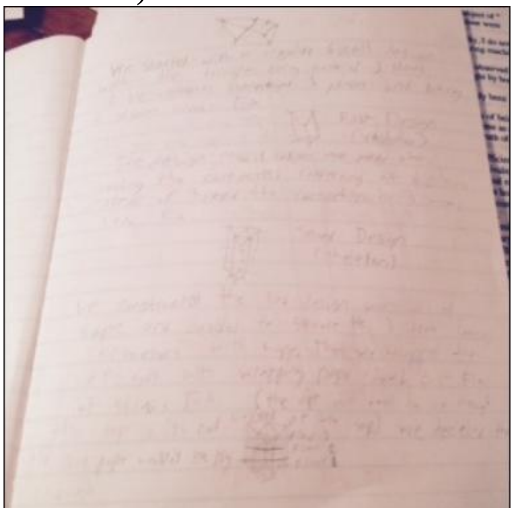
Formative assessment was used on a daily basis in the form of discussions and observations throughout the engineering process used for kite design. Students engaged in an in-depth discussion of the mathematical relationships involved in the form and function of kites. Then students tested their findings from the discussion by planning and redesigning their version of "Impossible Kite" by Jos DeMay. Evidence that showed students understanding surfaced through their discussion and statements on how simply changing the form of the kite – string placement, keeping the same rectangular shape but closing the shape and stacking it at different angles will ensure the function of flight. Students then applied those principles in creating a "Possible Kite." All of the students' kites did take flight for at least 10 seconds. Students were clearly on their way to meeting the content goal of solving real-world mathematical problems involving three-dimensional objects and developing an understanding of the effects of motion on those objects.

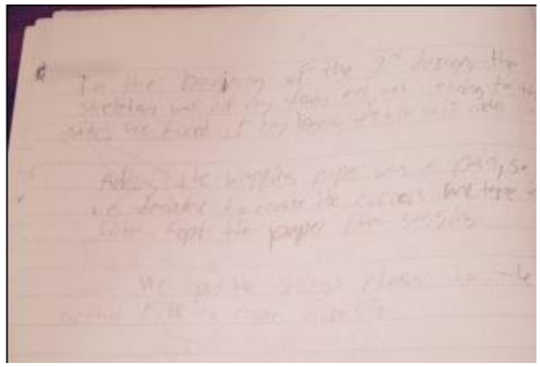
Students gained a deeper understanding of the mathematical relationships of kite design and began to understand the concept of how form influences function by reading and discussing "Tetrahedral Principle in Kite Structure" by Alexander Graham Bell. Students discussed how various three-dimensional shapes of design impact the intended purpose or function of the design by comparing and contrasting box kites, triangular celled kites, and various tetrahedral kites. They took into account the form - the materials, dimensions, surface area, volume, angles, faces, and placement of the cells in regards to function – how the kite would fly. They studied the diagrams and began to visualize flight patterns. Students continued to use the engineering process as they began their performance task.

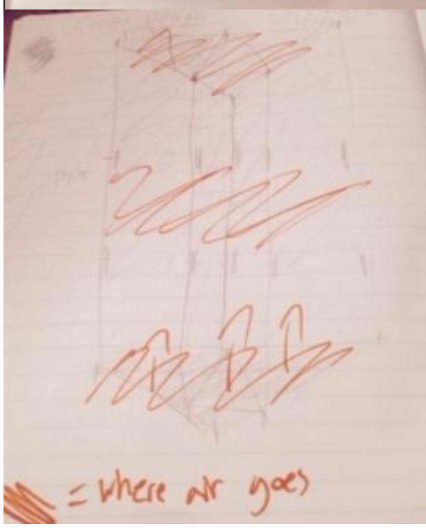
Summative assessment was product/process oriented through a performance task. Students became design engineers and collaborated with a partner to design, construct, and test their version of a three-dimensional tetrahedral kite. The task ended by summarizing the process using mathematics to describe form influencing function. Students developed problem solving skills with application to mathematics and engineering during the planning, design, testing, and redesign phases. Group one stated, “These dimensions look great on paper but it’s not working with the type of materials we have. We need to increase the surface area and change the placement of the cells.” They preceded to creatively use the limited supplies, foil wrap, dowels, and tape to form their kite, changing the pattern from individual rectangles to using an entire foil wrap and several dowels to create triangular shapes. Group two stated, “This tape is too heavy, what else can we do to get the straws to form a triangle?” They preceded to manipulate the straws by placing straws inside each other to form a two-dimensional triangle and then used string to tie the triangle to form a tetrahedral cell. Group three stated, “our kite doesn’t fly with low or high wind from the fan, but tries to lift with the medium wind from the fan. I wonder how we can get lift for more than one second.” They continued to reevaluate their kite’s structure, the materials used and then redesigned the kite using dowels with the straws, adding a tail, and readjusting the tension in the string.

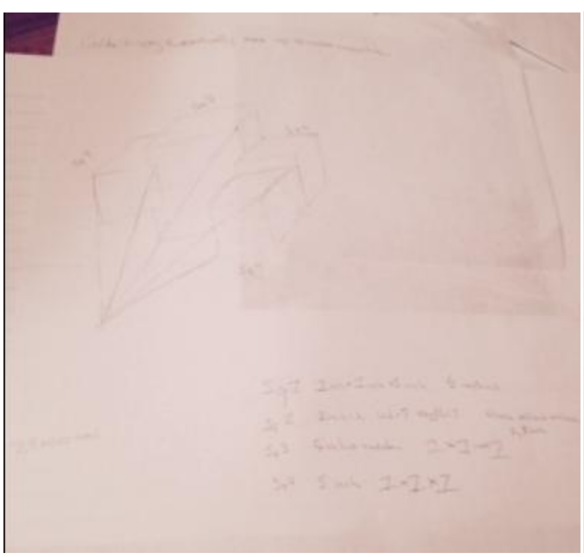
These students embraced failure and strengthened their creative problem solving skills to understand the relationships between mathematical formulas, structure, motion, and engineering phases. As each group presented their finding on the final day, they evaluated their experience of working through the engineering process. All six students concluded that patience, persistence, and trial and error are the keys to creatively problem solve with application to mathematics and engineering.

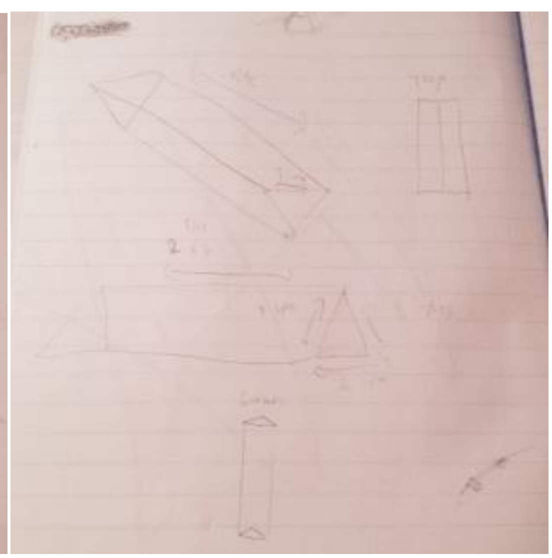
The following photo's are exerts from student notebooks highlighting the dimensions, sketches, design and redesign phases, and how forces of motion will lift the kites (taken over the 4 days of instruction).





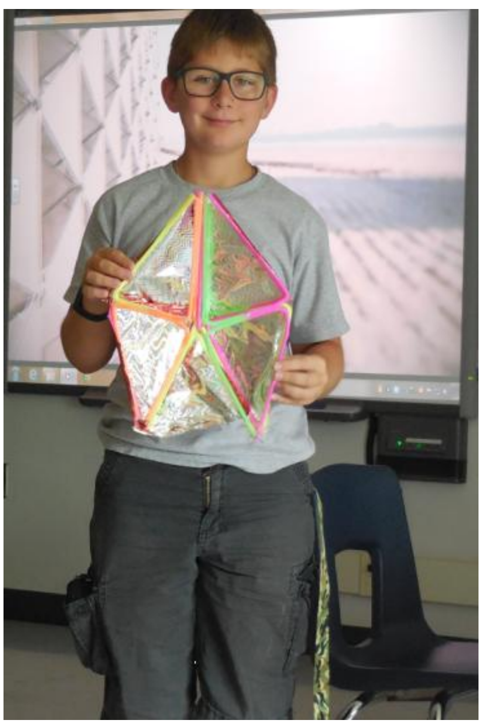


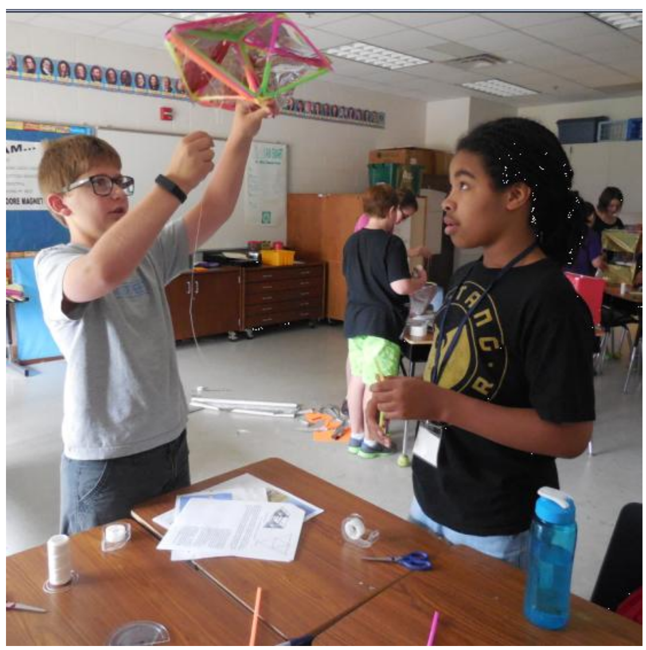




Students in final testing phase of kite.

Students in initial phase of kite design





Students' kite from middle of design phase – explained and applied dimensions/surface area formulas to construct form of kite. Students redesigning the form or placement of the string to ensure proper function of the kite.

V. Lesson Plans

TEACHER NAME	Lesson #
Adrienne Murchland	1

MODEL	CONTENT AREA	GRADE LEVEL
Visual Thinking Strategy	Mathematics - Geometry	7^{th}-8^{th}

CONCEPTUAL LENS	LESSON TOPIC
Form	Geometric Shapes - kites

LEARNING OBJECTIVES *(from State/Local Curriculum)*
7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms. 7.P.1 Understand motion, the effects of forces on motion and the graphical representations of motion.

THE ESSENTIAL UNDERSTANDING ***(What is the overarching idea students will understand as a result of this lesson?***	THE ESSENTIAL QUESTION ***(What question will be asked to lead students to "uncover" the Essential Understanding)***
Form Influences Function	How does form influence function?

CONTENT KNOWLEDGE **(What factual information will students learn in this lesson?)**	PROCESS SKILLS **(What will students be able to do as a result of this lesson?)**
*Know meaning of key vocabulary terms such as:*form-visible shape or configuration of something *function-an activity or purpose intended for a thing, purpose of existence dependent on something *adjacent- having a common vertex(corner point) and side that don't overlap *Complementary- two angles that add up to 90 degrees, can be a right angle but doesn't have to be *Supplementary-angles that add up to 180 degrees (is a straight line) and form a straight *surface area (SA) - total area of the surface of a 3D object. Formulas where l=length, w=width, h=height, B=base, P=perimeter, and b1=base one - SA rectangular (rec) prism = 2lw+2hw+2lh, SA of right pyramid = B+1/2Pl, SA of general prism=sum of the areas of the faces *area (A) – size of the surface. Formulas - A of rectangle = W*H, A of triangle=1/2B*h, A of parallelogram=b*h, A of circle=pi r^2,A of trapezoid=1/2(b1+b2)h *volume (V) - amount of 3-d space an object occupies or its capacity. V of rec prism=lwh, V of general prism=Bh, V of right pyramid=1/3Bh *perimeter- *Two-dimensional (2-D)- shape only has 2 dimensions like width and height, square,circle,triangle,etc *Three-dimensional (3-D) – shape has height, weight,	*Create calculations and explain the effects of those calculations on their designs. *Apply creative problem solving skills to understand mathematical formulas. *Analyze and infer how mathematical relationships influence form/function of flying objects *Apply, analyze, and evaluate the engineering process while creating their flying object through design, construction, testing, and redesign.

and depth like most objects in real world – sphere, cylinder, cone, cube, pyramid, prism. Polyhedral have flat surfaces and non-polyhedral do not have flat surfaces. Platonic surfaces have faces with same regular polygon that meet at each vertex. 5 types –*tetrahedron*-3 triangles meet at each vertex, 4 faces, 4 vertices, 6 edges, *cube*-3 squares meet at each vertex, 6 faces, 8 vertices, 12 edges, *octahedron*-4 triangles meet at each vertex, 8 faces, 6 vertices, 12 edges, *dodecahedron*-3 pentagons meet at each vertex, 12 faces, 20 vertices, 30 edges, *icosahedrons*, 5 triangles meet at each vertex, 20 faces, 12 vertices, 30 edges *polygon- closed plane figure with at least 3 or more straight sides and angles *right prisms –polygon base and vertical sides perpendicular to the base with base and top surface being same shape and size *cube– box with 6 identical square faces *quadrilateral- flat shape with 4 straight sides *edge- line where 2 surfaces meet, example tetrahedron has 6, or boundary of plane shape like circumference of circle *face- individual surfaces of a solid object, example tetrahedron has 4 faces *vertex (vertices)-point where 2 or more straight lines meet or a corner *Student will know the relationship between area and volume as well as area and surface area	

GUIDING QUESTIONS

What questions will be asked to support instruction?

Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
*What is the title of this painting? *What is significant about the shapes in this painting? *Why do you think the artist used these particular shapes in this painting? *What relationship do you see between this painting and mathematics? *How does the artist help you to see this mathematical relationship? *What is the significance of the title of this painting? *How can you mathematical prove or disprove that the title makes sense? *What strategies can you use to find area, surface area and volume of 2D	*How could volume and surface area be affected when dimensions of a figure are doubled? *How does surface area change when volume doesn't? *What do you notice about the form of the kite? *What do you notice about the string of the kite? *What function does the string have? *How can the form of the kite (placement of string, shape of kite) influence the function of the kite (lift, drag, weight, or tension of the flight)? *How did you use the relationship between form and function to	*How does the form of the kite change as you looked at the painting? *How is the design of the kite in the painting different than your own kite design? *What makes the title of this painting, "Impossible Kite" true or false? *What makes your design a possible kite, why? *How could the surface area of a 3-D shape/kite affect its lift or flight? *How could the placement of the string affect tension and drag? *How does form influence function?

and 3D shapes (triangles, quadrilaterals, polygons, cubes, and right prisms)? How are area and volume related?	influence your kite design? *How did you use a mathematical relationship to create your design?	

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
Impossible Kite by Jos de Mey is a painting that students have not explored to understand geometry concepts.	Students use critical thinking and observation to develop an understanding of how and why formulas work and relate to the measure (area and volume) of the figure.		

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

When students enter the classroom, the teacher hands them a picture entitled "Impossible Kite" by Jos de Mey (http://www.anopticalillusion.com/wp-content/uploads/2013/04/Impossible-Kite-by-Jos-de-Mey.jpg). Students are asked to quietly examine the content of the picture for about five minutes. They receive a note card where they can write down their thoughts based on the following questions – What can you infer about the title of the painting? How do you view the shape of the white figure? As you look at the 4 lines connected to the white object, how does the object appear to change?

After students complete the questions on their note card, the teacher asks the pre-lesson questions about the painting "Impossible Kite" which will be displayed on the smart board. The teacher gives time for student responses and facilitates a discussion.

What is the title of this painting?
What is significant about the title of this painting?
What is significant about the shapes in this painting?
Why do you think the artist used these particular shapes in this painting?
What relationship do you see between this painting and mathematics?
How does the artist help you to see this mathematical relationship?
How can you mathematical prove or disprove that the title makes sense?
What strategies can you use to find area, surface area and volume of 2D and 3D shapes (triangles, quadrilaterals, polygons, cubes, and right prisms)?
How are area and volume properties related to the function of the figure?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Students are given tools (rulers, protractors) and five to ten minutes to independently figure the dimensions of the figure in the picture. Students must consider the importance of form (height, length, width, shape, area, faces) as it influences function (flight, lift, drag, placement of the line/string). They are encouraged to accurately figure the dimensions based on how they view the object – can be individual cells or a set of two shapes. They will write their findings near the kite picture (underneath, on, or beside). After students determine dimensions they will work in pairs to complete a cause and effect graphic organizer on notebook paper (teacher illustrates on board fishbone map). The main idea is the title "Impossible Kite," they must come up with the causes (based on form of object) and the effect (function of kite) of why the painting of the kite is named impossible kite. The groups will share their best cause and effect with the class.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

After each pair of students shares their best cause/effect idea, the teacher asks the during-lesson questions. The teacher gives time for student responses, allowing comments and questions by their peers to facilitate a deeper discussion of how form influences function.

How could volume and surface area be affected when dimensions of a figure are doubled?
How does surface area change when volume doesn't?
What do you notice about the form of the kite?
What do you notice about the string of the kite?

What function does the string have?
How can the form of the kite (placement of string, shape of kite) influence the function of the kite (lift, drag, weight, or tension of the flight)?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Students are divided into pairs and asked to manipulate the design of the kite in the picture so that the title could no longer be "Impossible Kite." As you design or sketch your kite, consider what you know about form and function. Think about our discussion and draw the dimensions of your 3-D figure/kite, calculate the area and surface area, and pay close attention to the kite form (shape, angle, string) and how it influences function (flight of kite based on tension, lift, drag, weight, etc).

Teacher asks groups:
How did you use the relationship between form and function to influence your kite design?
How did you use a mathematical relationship to create your design?

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Students remain in groups and they are provided materials (straws, string, tissue paper, table cloth, tape, wooden dowels, glue, scissors, rulers, meter stick, etc.) They are asked to build the kite designed above. Then, they will write a summary of how their kite design is different (compare/contrast) than the painting they discussed previously. Students should include:
How the form of the kite changes as you looked at the painting? How design of the kite in the painting is different than their own kite design?
What makes the title of this painting, "Impossible Kite" true or false? What makes your design a possible kite, why?
How could the surface area of a 3-D shape/kite affect its lift or flight?
How could the placement of the string affect tension and drag?
How does form influence function?

Student Performance Task Description **Unit – Geometry – Form influences Function**

(Give to students on the end of Day 2 or Beginning of Day 3, based on understanding and how students accelerate through the curriculum)

The director of NASA's Glen Research Center is in the process of updating their Beginners Guide to Aeronautics website for students because of feedback from website users which suggest that the kite section needs a variety of examples of kite designs. As a junior design engineer, you are required to design a kite plan, construct a kite with simple materials, test the flight of your kite, and write a summary explaining the design, construction, and testing and redesign phases. In your submission, it is critical to include mathematical calculations such as angles, dimensions, area, surface area, volume, and/or other explanations of how the form of the kite influences the function of its flight. The website panel for NASA's Glen Research Center will review your submission to determine whether or not it will be included in the updated website.

Rubric

Category	Points
Kite design plan sketch includes dimensions and calculations	15
Simple materials used in kite construction	10
Kite construction is neat and durable	10
Summary includes explanation of design, construction, testing and redesign phases	15

TEACHER NAME			Lesson #
Adrienne Murchland			2
MODEL	CONTENT AREA	GRADE LEVEL	
Socratic Seminar	Mathematics	7^{th} -8^{th}	

CONCEPTUAL LENS	**LESSON TOPIC**
Form	Geometric Shapes – kites

LEARNING OBJECTIVES *(from State/Local Curriculum)*

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.
7.P.1 Understand motion, the effects of forces on motion and the graphical representations of motion.

THE ESSENTIAL UNDERSTANDING ***(What is the overarching idea students will understand as a result of this lesson?***	**THE ESSENTIAL QUESTION** ***(What question will be asked to lead students to "uncover" the Essential Understanding)***
Form Influence Function	How does form influence function?

CONTENT KNOWLEDGE **(What factual information will students learn in this lesson?)**	**PROCESS SKILLS** **(What will students be able to do as a result of this lesson?)**
*Know meaning of key vocabulary terms such as:*form-visible shape or configuration of something *function-an activity or purpose intended for a thing, purpose of existence dependent on something *adjacent- having a common vertex(corner point) and side that don't overlap *Complementary- two angles that add up to 90 degrees, can be a right angle but doesn't have to be *Supplementary-angles that add up to 180 degrees (is a straight line) and form a straight *surface area- total area of the surface of a 3D object. SA rec prism=2lw+2hw+2lh, SA of right pyramid = B+1/2Pl, SA of general prism=sum of the areas of the faces *area – size of the surface. A of rec=W*H, A of triangle=1/2B*h, A of parallelogram=b*h, A of circle=pi r^2,A of trapezoid=1/2(b1+b2)h *volume- amount of 3-d space an object occupies or its capacity. V of rec prism=lwh, V of general prism=Bh, V of right pyramid=1/3Bh *perimeter- *Two-dimensional (2-D)- shape only has 2 dimensions like width and height, square, circle, triangle, etc *Three-dimensional (3-D) – shape has height, weight, and depth like most objects in real world – sphere, cylinder, cone, cube, pyramid, and prism. Polyhedral have flat surfaces and non-polyhedral do not have flat surfaces. Platonic surfaces have faces with same regular polygon that meet at each vertex. 5 types –*tetrahedron*-3 triangles meet at each vertex, 4 faces, 4 vertices, 6 edges, *cube*-3 squares meet at each vertex, 6 faces, 8 vertices, 12 edges, *octahedron*-4 triangles meet at each	*Create calculations and explain the effects of those calculations on their designs. *Apply creative problem solving skills to understand mathematical formulas. *Analyze and infer how mathematical relationships influence form/function of flying objects *Apply, analyze, and evaluate the engineering process while creating their flying object through design, construction, testing, and redesign.

vertex, 8 faces, 6 vertices, 12 edges, *dodecahedron*-3 pentagons meet at each vertex, 12 faces, 20 vertices, 30 edges, *icosahedrons*, 5 triangles meet at each vertex, 20 faces, 12 vertices, 30 edges *polygon- closed plane figure with at least 3 or more straight sides and angles *right prisms –polygon base and vertical sides perpendicular to the base with base and top surface being same shape and size *cube– box with 6 identical square faces *quadrilateral- flat shape with 4 straight sides *edge- line where 2 surfaces meet, example tetrahedron has 6, or boundary of plane shape like circumference of circle *face- individual surfaces of a solid object, example tetrahedron has 4 faces *vertex (vertices)-point where 2 or more straight lines meet or a corner *Student will know the relationship between area and volume as well as area and surface area *3-D structures need to be proportional in size and weight to have successful lift and interaction with gravity Drag-frictional force acting on a body (plane/kite) moving through fluid like air parallel and opposite to the direction of motion Lift- force acting on plane/kite that's perpendicular to the wind and constitutes upward force that opposes the pull of gravity Gravity-force between two objects due to the mass of the object and the distance separating them Tension-two pulling forces opposing each other that stretch an object. (for example, tension in string keeps kite from flying further away) Relative wind-airflow produced by the object moving through the air, direction is parallel with and opposite to direction of flight	

GUIDING QUESTIONS *What questions will be asked to support instruction?* *Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding*		
Pre-Lesson Questions:	**During Lesson Questions:**	**Post Lesson Questions:**
*What is the most important part or form of a 3-D kite? *How does the triangular shape or form contribute to the success of the lift or its function? *How does the number of tetrahedron cells or its form influence the success or failure of its function of flight? *What are the most influential forms of successful function of flight of a tetrahedron kite and why?	*How does the form, such as volume and surface area affect the weight of the tetrahedron? *What impact does the frame of the tetrahedron have on the overall structure? *What is the relationship between the frame, dimensions and weight of the four celled and sixteen celled tetrahedron kites? *How does the form of the kite change as the cells increase? *How could the different forms of the triangular wings affect the function of flight? *In regards to force of motion or function, what would be the ideal materials to use when creating the tetrahedron cells and why?	*How can the form of 3-D kites influence a change in the function of flight? *If you were to design a tetrahedron kite what improvement would you make to its form to influence its function of flight and why? *If you could ask Bell a question about tetrahedron kites, what would it be and why? *How does form influence function?

DIFFERENTIATION *(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.*			
Content	**Process**	**Product**	**Learning Environment**
	Students critically think and mathematically analyze the form and function of tetrahedral kites as they read, interpret, listen, question, and make inferences during the Socratic seminar		Students collaborate with partners and work independently to discover the mathematical relationships relating to form and function of tetrahedron kites.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

Students enter classroom grab a task card and view short video clip of a tetrahedron structure taking flight: https://vimeo.com/33342571. As students watch the video clip they are answering the following questions on the task card: What is the most important part of this kite? What is necessary for this object to take flight or function properly? How can the form of an object of that size take flight or function without any complications?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Students read the following article:

TETRAHEDRAL PRINCIPLE IN KITE STRUCTURE by Alexander Graham Bell (President of the National Geographic Society) *(Reprint from National Geographic Magazine Vol. XIV, No.6, June 1903)*

http://britton.disted.camosun.bc.ca/bell/bell.htm

Students are given a copy of the above article and asked to independently read article using a close read strategy - break it apart by circling key vocabulary, summarizing key concepts, writing questions or ideas that need to be explored, and underlining important details. The teacher will demonstrate by illustrating a close read of the introduction aloud. Students will then close read the article beginning with Hargrave's Box Kite section (possibly take 10 to 15 minutes). As students read, they need to be thinking about: *How does the triangular shape or form contribute to the success of the lift or its function? *What are the most influential forms of successful function of flight of a tetrahedron kite and why?

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

Teacher divides class in small groups so they can discuss article in an inside/outside circle (at least 3 students in each group). Outside circle takes notes based on student discussion – who contributed, what was said, whether text was cited and questions were posed. Inside circle begins discussion based on teacher's question, "How can you explain whether a triangular shape has greater lifting power than other three dimensional shapes? After 5 to 10 minutes, the inner/outer circle change roles/places.

If needed, teacher can facilitate the discussion by asking any of the following questions: *How does the form, such as volume and surface area affect the weight of the tetrahedron? *What impact does the frame of the tetrahedron have on the overall structure? *What is the relationship between the frame, dimensions and weight of the four celled and sixteen celled tetrahedron kites? *How does the form of the kite change as the cells increase? *How could the different forms of the triangular wings affect the function of flight? *In regards to force of motion or function, what would be the ideal materials to use when creating the tetrahedron cells and why?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Students continue to discuss the mathematics behind tetrahedral construction of kites and lift power examining the different type of triangular tetrahedrons and the amount of cells. Pairs of students will take a closer look at Figures 1 – 20 in the reading. Then discuss how the dimensions changed as the cells increased, how different triangular wings may influence the flight, what materials could be used to influence the best flight and why? Students can use a graphic organizer or sketch the different tetrahedral cells to collect their thoughts and continue with the discussion.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Students write a reflection of their summary of learning based on 3-D kites and their flight. Their summary must focus on the following questions: *How can the form of 3-D kites influence a change in the function of flight? *If you were to design a tetrahedron kite what improvement would you make to its form to influence its function of flight and why? *If you could ask Bell a question about tetrahedron kites, what would it be and why? *How does form influence function?

Then design a plan to create an original tetrahedron kite. Their plain must include a list of materials, dimensions and number of cells, sketch or drawing, and hypothesize why their kite will fly.

Rubric

	Criteria	Points	Possible Points
Material List	Practical		5
Sketch of Kite	Neatly drawn		5
Calculations/Dimensions	Correct		10

	measurements	
Hypothesis	Explanation has concrete details and ideas that include how form influences function.	10

Teacher will evaluate students kite design plans so that feedback can be given and changes can be carried into the performance task on day three.

TEACHER NAME			Lesson #
Adrienne Murchland			3
MODEL	CONTENT AREA	GRADE LEVEL	
Creative Problem Solving	Mathematics	7^{th} -8^{th}	

CONCEPTUAL LENS	**LESSON TOPIC**
Form	Geometric Shapes – kites

LEARNING OBJECTIVES *(from State/Local Curriculum)*

7. G.6 Solve real-world and mathematical problems involving area, volume and surface area of two and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.
7. P.1 Understand motion, the effects of forces on motion and the graphical representations of motion.

THE ESSENTIAL UNDERSTANDING ***(What is the overarching idea students will understand as a result of this lesson?***	**THE ESSENTIAL QUESTION** ***(What question will be asked to lead students to "uncover" the Essential Understanding)***
Form Influence Function	How does form influence function?

CONTENT KNOWLEDGE **(What factual information will students learn in this lesson?)**	**PROCESS SKILLS** **(What will students be able to do as a result of this lesson?)**
*Know meaning of key vocabulary terms such as:*form-visible shape or configuration of something *function-an activity or purpose intended for a thing, purpose of existence dependent on something *adjacent- having a common vertex(corner point) and side that don't overlap *Complementary- two angles that add up to 90 degrees, can be a right angle but doesn't have to be *Supplementary-angles that add up to 180 degrees (is a straight line) and form a straight *surface area (SA) - total area of the surface of a 3D object. Formulas where l=length, w=width, h=height, B=base, P=perimeter, and b1=base one - SA rectangular (rec) prism = 2lw+2hw+2lh, SA of right pyramid = B+1/2Pl, SA of general prism=sum of the areas of the faces *area (A) – size of the surface. Formulas - A of rectangle = W*H, A of triangle=1/2B*h, A of parallelogram=b*h, A of circle=pi r^2,A of trapezoid=1/2(b1+b2)h *volume (V) - amount of 3-d space an object occupies or its capacity. V of rec prism=lwh, V of general prism=Bh, V of right pyramid=1/3Bh *perimeter- *Two-dimensional (2-D)- shape only has 2 dimensions like width and height, square,circle,triangle,etc *Three-dimensional (3-D) – shape has height, weight, and depth like most objects in real world – sphere, cylinder, cone, cube, pyramid, and prism. Polyhedral have flat surfaces and non-polyhedral do not have flat surfaces. Platonic surfaces have faces with same regular	*Create calculations and explain the effects of those calculations on their designs. *Apply creative problem solving skills to understand mathematical formulas. *Analyze and infer how mathematical relationships influence form/function of flying objects *Apply, analyze, and evaluate the engineering process while creating their flying object through design, construction, testing, and redesign.

polygon that meet at each vertex. 5 types –*tetrahedron*-3 triangles meet at each vertex, 4 faces, 4 vertices, 6 edges, *cube*-3 squares meet at each vertex, 6 faces, 8 vertices, 12 edges, *octahedron*-4 triangles meet at each vertex, 8 faces, 6 vertices, 12 edges, *dodecahedron*-3 pentagons meet at each vertex, 12 faces, 20 vertices, 30 edges, *icosahedrons*, 5 triangles meet at each vertex, 20 faces, 12 vertices, 30 edges *<u>polygon</u>- closed plane figure with at least 3 or more straight sides and angles *<u>right prisms</u> –polygon base and vertical sides perpendicular to the base with base and top surface being same shape and size *<u>cube</u>– box with 6 identical square faces *<u>quadrilateral</u>- flat shape with 4 straight sides *<u>edge</u>- line where 2 surfaces meet, example tetrahedron has 6, or boundary of plane shape like circumference of circle *<u>face</u>- individual surfaces of a solid object, example tetrahedron has 4 faces *<u>vertex (vertices)-</u>point where 2 or more straight lines meet or a corner *Student will know the relationship between area and volume as well as area and surface area	

GUIDING QUESTIONS

What questions will be asked to support instruction?

Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
*What geometric shape is the strongest and why? *How are triangles (single and multiple units) used in the construction of various structures such as bridges and towers? *What makes this form ideal for building structures? *How does making an airplane larger allow it to carry larger and heavier objects? *Why did you choose the specific materials for your kite from the previous day's activity? *Why do you think you will or will not need to modify your design? *How can the weight of the materials affect the kite's function? *What other aspects of the form of the kite will influence a successful lift from the ground?	*How can you rearrange the cells to change the form? *As you rearrange the cells, why does the placement of the bridle need to change? *How do you create stability in your tetrahedral kite? *How has your design changed and why? *How have the materials you chose impacted your initial design? *As your design plan now becomes a form, can you explain how it will influence its function of flight? *How can you rearrange the cells to change the form? *As you rearrange the cells, why does the placement of the bridle need to change? * How do you create stability in your tetrahedral kite?	*What would you do differently in the design and test phases of your kite project? *How did you develop a solution to any design issues with the kites form or function? *How did the form of your kite restrict or excel its function? *How does form influence function?

DIFFERENTIATION *(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.*			
Content	**Process**	**Product**	**Learning Environment**
	Students will collaborate with a partner to apply, analyze, and evaluate the engineering process while creating their flying object (kite). They will create a successful flight through the design; construction, testing, and redesign phases.		

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

Students will follow the engineering process by continuing with their kite design plan. They will be given the following task:

The director of NASA's Glen Research Center is in the process of updating their Beginners Guide to Aeronautics website for students because of feedback from website users which suggest that the kite section needs a variety of examples of kite designs.

As a junior design engineer, you are required to design a kite plan, construct a kite with simple materials, test the flight of your kite, and write a summary explaining the design, construction, and testing and redesign phases. In your submission, it is critical to include mathematical calculations such as angles, dimensions, area, surface area, volume, and/or other explanations of how the form of the kite influences the function of its flight. The website panel for NASA's Glen Research Center will review your submission to determine whether or not it will be included in the updated website.

Rubric

Category	Points
Kite design plan sketch includes dimensions and calculations	15
Simple materials used in kite construction	10
Kite construction is neat and durable	10
Summary includes explanation of design, construction, testing and redesign phases	15

After students read the task, the teacher will ask the following questions to facilitate a 5 minute discussion to recap a summary of learning from yesterday's activities: Yesterday we explored the variations of tetrahedral kites with types of triangular cells think about: What geometric shape is the strongest and why? How are triangles (single and multiple units) used in the construction of various structures such as bridges and towers? What makes this form ideal for building structures? How does making an airplane larger allow it to carry larger and heavier objects? Why did you choose the specific materials for your kite from the previous day's activity? Why do you think you will or will not need to modify your design? How can the weight of the materials affect the kite's function? What other aspects of the form of the kite will influence a successful lift from the ground?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Students will complete their design from the previous day if needed; otherwise, they will follow their plan to build their tetrahedral kite. As students build their kites the teacher will facilitate students understanding of how form influences function by asking: How can you rearrange the cells to change the form? As you rearrange the cells, why does the placement of the bridle need to change? How do you create stability in your tetrahedral kite?

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

As they begin the initial test of their kite they will take notes along the way of what works and what changes or redesigns will be necessary to create a kite that will fly. This is where students should be able to determine if the materials used were too heavy, not strong enough, whether or not the actual construction is correct with the dimensions, angles, and how the kites form influences its function. They will record this type of data in their notebook (For example, Trial flight 1, 2, and 3 – take into account placement of string, length and number of tails, placement of the tail, number of cells, size of cells, area of cells, weight of kite materials, etc.). Students may use a fan in the classroom to create an initial test of how the kite flies.

During this process the teacher will ask: How has your design changed and why? How have the materials you chose impacted your initial design? As your design plan now becomes a form, can you explain how it will influence its function of flight?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Students will be giving ample opportunity to make any adjustments to their kites based on their testing process. They will then make any notation to what changes occurred and why. During this process the teacher will ask:

What would you do differently in the design and test phases of your kite project?
How did you develop a solution to any design issues in regards to form and function?
Explain why your kite did or did not stay airborne for at least 10 seconds.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

NOTE - Students may or may not get to this portion of the lesson based on the time they need to design, test, redesign, and retest their kites. After students completed the kite design, construction, and testing phase they will complete the project by writing a summary that includes how "form influences function." They will be able to explain how many factors such as geometry (angles, shapes, proportions) materials, weight, and the structure or form influences the function or flight of the kite. They will be able to explain the changes they made and why as it relates to form influencing function based on their testing phase.

TEACHER NAME			Lesson #
Adrienne Murchland			4
MODEL	CONTENT AREA	GRADE LEVEL	
Creative Problem Solving	Mathematics	7th -8th	
CONCEPTUAL LENS		**LESSON TOPIC**	
Form		Geometric Shapes – kites	
LEARNING OBJECTIVES *(from State/Local Curriculum)*			

7. G.6 Solve real-world and mathematical problems involving area, volume and surface area of two and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.
7. P.1 Understand motion, the effects of forces on motion and the graphical representations of motion.

THE ESSENTIAL UNDERSTANDING ***(What is the overarching idea students will understand as a result of this lesson?***	**THE ESSENTIAL QUESTION** ***(What question will be asked to lead students to "uncover" the Essential Understanding)***
Form Influence Function	How does form influence function?
CONTENT KNOWLEDGE **(What factual information will students learn in this lesson?)**	**PROCESS SKILLS** **(What will students be able to do as a result of this lesson?)**
*Know meaning of key vocabulary terms such as:*form-visible shape or configuration of something *function-an activity or purpose intended for a thing, purpose of existence dependent on something *adjacent- having a common vertex(corner point) and side that don't overlap *Complementary- two angles that add up to 90 degrees, can be a right angle but doesn't have to be *Supplementary-angles that add up to 180 degrees (is a straight line) and form a straight *surface area (SA) - total area of the surface of a 3D object. Formulas where l=length, w=width, h=height, B=base, P=perimeter, and b1=base one - SA rectangular (rec) prism = 2lw+2hw+2lh, SA of right pyramid = B+1/2Pl, SA of general prism=sum of the areas of the faces *area (A) – size of the surface. Formulas - A of rectangle = W*H, A of triangle=1/2B*h, A of parallelogram=b*h, A of circle=pi r^2,A of trapezoid=1/2(b1+b2)h *volume (V) - amount of 3-d space an object occupies or its capacity. V of rec prism=lwh, V of general prism=Bh, V of right pyramid=1/3Bh *perimeter- *Two-dimensional (2-D)- shape only has 2 dimensions like width and height, square,circle,triangle,etc *Three-dimensional (3-D) – shape has height, weight, and depth like most objects in real world – sphere, cylinder, cone, cube, pyramid, and prism. Polyhedral have flat surfaces and non-polyhedral do not have flat surfaces. Platonic surfaces have faces with same regular polygon that meet at each vertex. 5 types –*tetrahedron*-3 triangles meet at each vertex, 4 faces, 4 vertices, 6 edges, *cube*-3 squares meet at each vertex, 6 faces, 8 vertices, 12 edges, *octahedron*-4 triangles meet at each vertex, 8 faces, 6 vertices, 12 edges, *dodecahedron*-3 pentagons meet at each vertex, 12 faces, 20 vertices, 30 edges, *icosahedrons*, 5 triangles meet at each vertex, 20 faces, 12 vertices, 30 edges *polygon- closed plane figure with at least 3 or more	*Create calculations and explain the effects of those calculations on their designs. *Apply creative problem solving skills to understand mathematical formulas. *Analyze and infer how mathematical relationships influence form/function of flying objects *Apply, analyze, and evaluate the engineering process while creating their flying object through design, construction, testing, and redesign.

straight sides and angles *right prisms –polygon base and vertical sides perpendicular to the base with base and top surface being same shape and size *cube– box with 6 identical square faces *quadrilateral- flat shape with 4 straight sides *edge- line where 2 surfaces meet, example tetrahedron has 6, or boundary of plane shape like circumference of circle *face- individual surfaces of a solid object, example tetrahedron has 4 faces *vertex (vertices)-point where 2 or more straight lines meet or a corner *Student will know the relationship between area and volume as well as area and surface area	

GUIDING QUESTIONS *What questions will be asked to support instruction?* *Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding*		
Pre-Lesson Questions:	**During Lesson Questions:**	**Post Lesson Questions:**
*What was the biggest challenge you faced yesterday as you worked through the building, testing, and redesign phases? *How will flight take place? *How or why will gravity, lift, force, etc. be different in comparison to the tetrahedral kite? * How does the form and function of your new object compare to the form and function of the tetrahedral kite?	* How is the structure of this object different from your tetrahedral kite? * Make a hypothesis of how the area, volume, or weight of your object will affect its flight? * How did you get your object to launch or fly? *How did you cause lift with your flying object? *What force or forces were opposing the forward motion of your flying object due to thrust and the upward motion due to lift? *How did the design of your flying object affect the way it moved through air? *How did the changes you made to its design change the motion of the object? Why?	*What would you do differently in the final design and test phases today? *What design issues surfaced as you participated in the final testing phase? *How did you need to redesign your kite in order for its form to influence its function to fly? *How does form influence function?

DIFFERENTIATION *(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.*			
Content	**Process**	**Product**	**Learning Environment**
	Students will collaborate with a partner to apply, analyze, and evaluate the engineering process while creating their flying object (kite). They will create a successful flight through the design; construction, testing, and redesign phases.		

PLANNED LEARNING EXPERIENCES *(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)*
Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.* Today you will continue to be design engineers. You will be given time to complete the testing and redesign phases of your kite if you did not finish. Those of you who have finished will be given an opportunity to create a third and final flying object. You can choose between making a parachute or a glider. Before you begin, turn to a new page in your notebook/journal and answer the following questions that pertain to where you left off from the previous

day - What was the biggest challenge you faced yesterday as you worked through the building, testing, and redesign phases? How will flight take place? How or why will gravity, lift, force, etc. be different in comparison to the tetrahedral kite? How does the form and function of your new object compare to the form and function of the tetrahedral kite? Teacher gives LP -4 question strips to students to glue in their notebooks so they can reflect/hypothesis/write appropriate ideas and thoughts.

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Students continue to work from previous day or begin new design of third flying object.

For those students who will begin their new design, they will take a few minutes to look at the different types of materials (paper, foam, plastic, string, paper clips, skewers, rubber bands, cardboard, wire, cups, straws, etc.) Then they will go back to their desks and spend 5 to 10 minutes sketching their flying object and listing the materials they will use. They will also answer any of the questions strips in which they did not answer in the beginning of class.

For those students who are continuing with the previous day's work will continue to take notes – record data, reflect, analyze, and test the form of their kite in order to create a successful flight, or ensure proper function of the kite.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

For those students who will begin their new design, they will collect supplies they need and begin to build their flying object based off of their sketch. The students have 30 minutes to construct their third flying object. The teacher will facilitate learning by asking: how is the structure of this object different from your tetrahedral kite? Make a hypothesis of how the area, volume, or weight of your object will affect its flight? Students will continue to collect /record data in their notebooks about the design, the objects form, and hypothesize about how the structure or form of the object will restrict or make its function successful.

For those students who are continuing with the previous day's work they will continue with analyzing the testing phase in order to make the necessary re-design to reach their objects proper function.

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

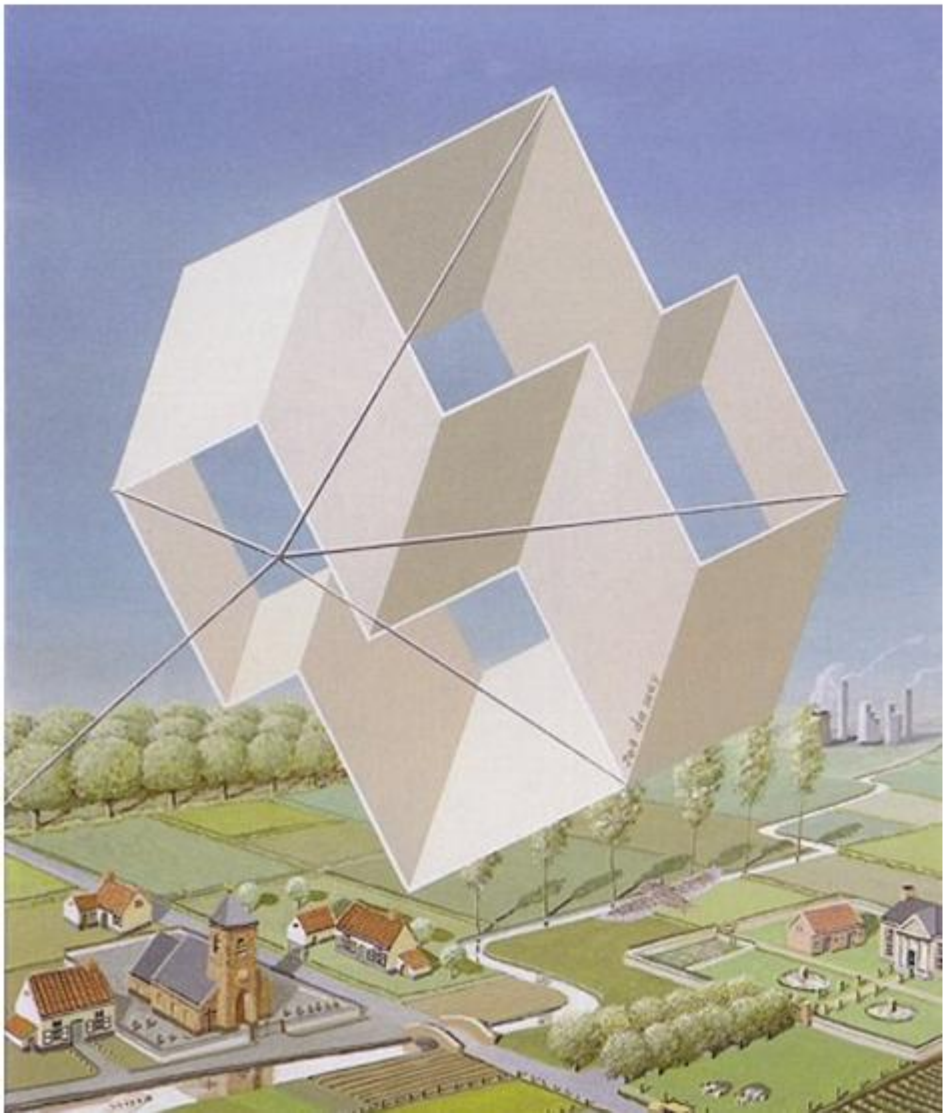
Students will be given time to complete a final test flight of all three objects (kite from first day, tetrahedral kite, and third object). Students will answer the following questions as they record their data: What would you do differently in the final design and test phases today? What design issues surfaced as you participated in the final testing phase? How did you need to redesign your kite in order for its form to influence its function to fly? How does form influence function?

Students will be given an opportunity to listen to a guest speaker, Marshall L. Ihrig, Jr., a former Navy Pilot and Physicist briefly speak about his life experiences and how Mathematics, Engineering, and Science affected his journey in life. Students will then have a "Ask the speaker" session and then each partner pair will have a three to five minutes to summarize their kite design and demonstrate their kite flight (using a fan for wind) for Mr. Ihrig, Jr. to comment and judge their work.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Students will complete the last portion of the performance task by writing a summary explaining the design, construction, and testing and redesign phases. Their submission must include mathematical calculations such as angles, dimensions, area, surface area, volume, and/or other explanations of how the form of the kite influences the function of its flight.

Students (partner pairs) will be given five minutes to speak in front of their peers, describing their designs, the processes they went through, the challenges and rewards of completing their performance task, and then answering any questions from their classmates. Each student will state how they believe form influences function.



http://www.anopticalillusion.com/wp-content/uploads/2013/04/Impossible-Kite-by-Jos-de-Mey.jpg
Handout given out on Day 1

https://vimeo.com/33342571
Video played on Day 2 and Day 3

<u>LP 4 – question strips (engage & connect) for 6 students (teacher cuts/passes out)</u>

What was the biggest challenge you faced yesterday as you worked through the building, testing, and redesign phases?

How will flight take place?

How or why will gravity, lift, force, etc. be different in comparison to the tetrahedral kite?

How does the form and function of your new object compare to the form and function of the tetrahedral kite?

What was the biggest challenge you faced yesterday as you worked through the building, testing, and redesign phases?

How will flight take place?

How or why will gravity, lift, force, etc. be different in comparison to the tetrahedral kite?

How does the form and function of your new object compare to the form and function of the tetrahedral kite?

What was the biggest challenge you faced yesterday as you worked through the building, testing, and redesign phases?

How will flight take place?

How or why will gravity, lift, force, etc. be different in comparison to the tetrahedral kite?

How does the form and function of your new object compare to the form and function of the tetrahedral kite?

What was the biggest challenge you faced yesterday as you worked through the building, testing, and redesign phases?

How will flight take place?

How or why will gravity, lift, force, etc. be different in comparison to the tetrahedral kite?

How does the form and function of your new object compare to the form and function of the tetrahedral kite?

What was the biggest challenge you faced yesterday as you worked through the building, testing, and redesign phases?

How will flight take place?

How or why will gravity, lift, force, etc. be different in comparison to the tetrahedral kite?

How does the form and function of your new object compare to the form and function of the tetrahedral kite?

What was the biggest challenge you faced yesterday as you worked through the building, testing, and redesign phases?

How will flight take place?

How or why will gravity, lift, force, etc. be different in comparison to the tetrahedral kite?

How does the form and function of your new object compare to the form and function of the tetrahedral kite?

Handout (by Alexander Graham Bell given out on Day 2/students referenced it Day 3/4

TETRAHEDRAL PRINCIPLE IN KITE STRUCTURE

by Alexander Graham Bell (President of the National Geographic Society)

(Reprint from National Geographic Magazine Vol. XIV, No.6, June 1903)

In 1899, at the April meeting, I made a communication to the Academy upon the subject of " Kites with Radial Wings" and some of the illustrations shown to the Academy at that time were afterwards published in the *Monthly Weather Review*.

Since then I have been continuously at work upon experiments relating to kites. Why, I do not know, excepting perhaps because of the intimate connection of the subject with the flying-machine problem.

We are all of us interested in aerial locomotion; and I am sure that no one who has observed with attention the flight of birds can doubt for one moment the possibility of aerial flight by bodies specifically heavier than the air.

In the words of an old writer, "We cannot consider as impossible that which has already been accomplished."

I have had the feeling that a properly constructed flying-machine should be capable of being flown as a kite; and, conversely, that a properly constructed kite should be capable of use as a flying-machine when driven by its own propellers. I am not so sure, however, of the truth of the former proposition as I am of the latter.

Given a kite, so shaped as to be suitable for the body of a flying-machine, and so efficient that it will fly well in a good breeze (say 20 miles an hour) when loaded with a weight equivalent to that of a man and engine; then it seems to me that this same kite, provided with an actual engine and man in place of the load, and driven by its own propellers at the rate of 20 miles an hour, should be sustained in calm air as a flying-machine. So far as the pressure of the air is concerned, it is surely immaterial whether the air moves against the kite, or the kite against the air.

Of course in other respects the two cases are not identical. A kite sustained by a 20-mile breeze possesses no momentum, or rather its momentum is equal to zero, because it is stationary in the air and has no motion proper of its own; but the momentum of a heavy body propelled at 20 miles an hour through still air is very considerable. Momentum certainly aids flight, and it may even be a source of support against gravity quite independently of the pressure of the air. It is perfectly possible, therefore, that an apparatus may prove to be efficient as a flying-machine which cannot be flown as a kite on account of the absence of *vis viva*.

However this may be, the applicability of kite experiments to the flying-machine problem has for a long time past been the guiding thought in my researches.

I have not cared to ascertain how high a kite may be flown or to make one fly at any very great altitude. The point I have had specially in mind is this: That the equilibrium of the structure in the air should be perfect; that the kite should fly steadily, and not move about from side to side or dive suddenly when struck by a squall, and that when released it should drop slowly and gently to the ground without material oscillation. I have also considered it important that the framework should possess great strength with little weight.

I believe that in the form of structure now attained the properties of strength, lightness, and steady flight have been united in a remarkable degree.

In my younger days the word "kite" suggested a structure of wood in the form of a cross covered with paper forming a diamond-shaped surface longer one way than the other, and provided with a long tail composed of a string with numerous pieces of paper tied at intervals upon it. Such a kite is simply a toy. In Europe and America, where kites of this type prevailed, kite-flying was pursued only as an amusement for children, and the improvement of the form of structure was hardly considered a suitable subject of thought for a scientific man.

In Asia kite-flying has been for centuries the amusement of adults, and the Chinese, Japanese, and Malays have developed tailless kites very much superior to any form of kite known to us until quite recently.

It is only within the last few years that improvements in kite structure have been seriously considered, and the recent developments in the art have been largely due to the efforts of one man - Mr. Laurence Hargrave, of Australia.

Hargrave realized that the structure best adapted for what is called a "good kite" would also be suitable as the basis for the structure of a flying-machine. His researches, published by the Royal Society of New South Wales, have attracted the attention of the world, and form the starting point for modern researches upon the subject in Europe and America.

Anything relating to aerial locomotion has an interest to very many minds, and scientific kite-flying has everywhere been stimulated by Hargrave's experiments.

In America, however, the chief stimulus to scientific kite-flying has been the fact developed by the United States Weather Bureau, that important information could be obtained concerning weather conditions if kites could be constructed capable of lifting meteorological instruments to a great elevation in the free air. Mr. Eddy and others in America have taken the Malay tailless kite as a basis for their experiments, but Professor Marvin, of the United States Weather Bureau; Mr. Rotch, of the Blue Hill Observatory, and many others have adapted Hargrave's box kite for the purpose.

Congress has made appropriations to the Weather Bureau in aid of its kite experiments, and a number of meteorological stations throughout the United States were established a few years ago equipped with the Marvin kite.

Continuous meteorological observations at a great elevation have been made at the Blue Hill Observatory in Massachusetts, and Mr. Rotch has demonstrated the possibility of towing kites at sea by means of steam vessels so as to secure a continuous line of observations all the way across the Atlantic.

HARGRAVE'S BOX KITE

Hargrave introduced what is known as the "cellular construction of kites." He constructed kites composed of many cells, but found no substantial improvement in many cells over two alone; and a kite composed of two rectangular cells separated by a considerable space is now universally known as "the Hargave box kite". This represents, in my opinion, the high-water mark of progress in the nineteenth century; and this form of kite forms the starting point for my own researches (Fig.1).

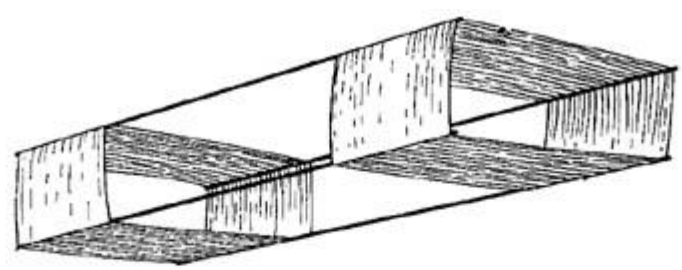


FIG. 1 — HARGRAVE BOX KITE

The front and rear cells are connected together by a framework, so that a considerable space is left between them. This space is an essential feature of the kite: upon it depends the fore and aft stability of the kite. The greater the space, the more stable is the equilibrium of the kite in a fore and aft direction, the more it tends to assume a horizontal position in the air, and the less it tends to dive or pitch like a vessel in a rough sea. Pitching motions or oscillations are almost entirely suppressed when the space between the cells is large.

Each cell is provided with vertical sides; and these again seem to be essential elements of the kite contributing to lateral stability. The greater the extent of the vertical sides, the greater is the stability in the lateral direction, and the less tendency has the kite to roll, or move from side to side, or turn over in the air.

In the foregoing drawing I have shown only necessary details of construction, with just sufficient framework to hold the cells together.

It is obvious that a kite constructed as shown in Fig.1 is a very flimsy affair. It requires additions to the framework of various sorts to give it sufficient strength to hold the aeroplane surfaces in their proper relative positions and prevent distortion, or bending or twisting of the kite frame under the action of the wind.

Unfortunately the additions required to give rigidity to the framework all detract from the efficiency of the kite:

First, by rendering the kite heavier, so that the ratio of weight to surface is increased; and, secondly, by increasing the head resistance of the kite. The interior bracing advisable in order to preserve the cells from distortion comes in the way of the wind, thus adding to the *drift* of the kite without contributing to the *lift*.

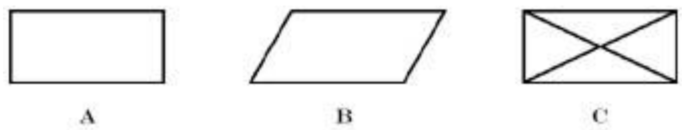


FIG. 2

A rectangular cell like A (Fig.2) is structurally weak, as can readily be demonstrated by the little force required to distort it into the form shown at B. In order to remedy this weakness, internal bracing is advisable of the character shown at C.

This internal bracing, even if made of the finest wire, so as to be insignificant in weight, all comes in the way of the wind, increasing the head resistance without counterbalancing advantages.

TRIANGULAR CELLS IN KITE CONSTRUCTION

In looking back over the line of experiments in my own laboratory, I recognize that the adoption of a triangular cell was a step in advance, constituting indeed one of the milestones of progress, one of the points that stand out clearly against the hazy background of multitudinous details. The following (Fig.3) is a drawing of a typical triangular-celled kite made upon the same general model as the Hargrave box kite shown in Fig.1.

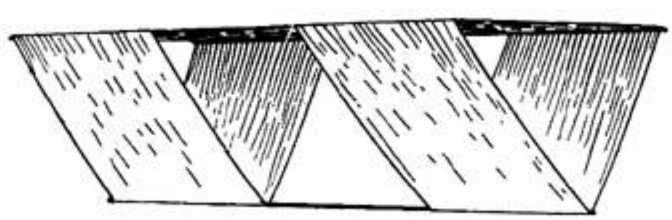


FIG. 3

A triangle is by its very structure perfectly braced in its own plane, and in a triangular-celled kite like that shown in Fig. 3, internal bracing of any character is unnecessary to prevent distortion of a kind analogous to that referred to above in the case of the Hargrave rectangular cell (Fig.2).

The lifting power of such a triangular cell is probably less than that of a rectangular cell, but the enormous gain in structural strength, together with the reduction of head resistance and weight due to the omission of internal bracing, counterbalances any possible deficiency in this respect.

The horizontal surfaces of a kite are those that resist descent under the influence of gravity, and the vertical surfaces prevent it from turning over in the air. Oblique aeroplanes may therefore conveniently be resolved into horizontal and vertical equivalents, that is, into supporting surfaces and steadying surfaces.

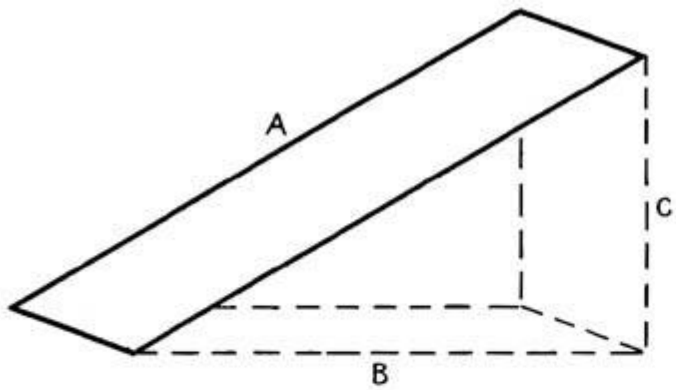


FIG. 4

The oblique aeroplane A,for example (Fig.4),may be considered as equivalent in function to the two aeroplanes B and C. The material composing the aeroplane A however, weightless than the material required to form the two aeroplanes B and C, and the framework required to support the aeroplane A weighs less than the two frameworks required to support B and C.

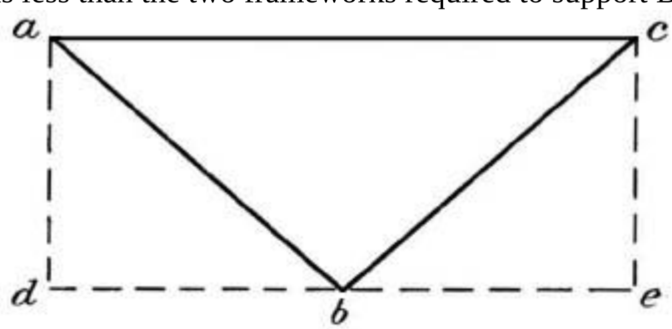


FIG. 5

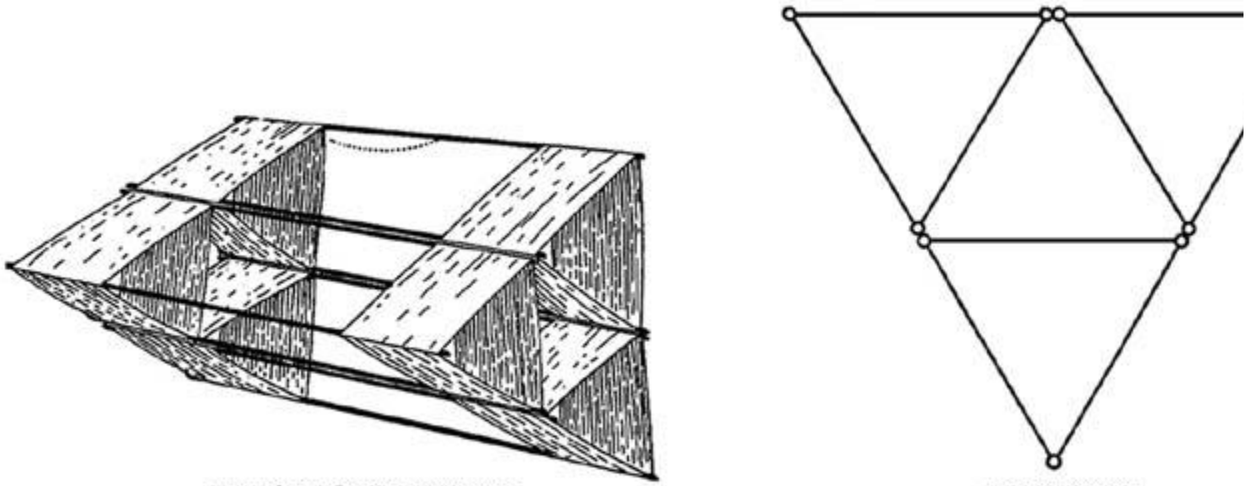
In the triangular cell shown in Fig.5, the oblique surfaces ab, bc, are equivalent in function to the three surfaces ad, de, ec, but weigh less. The oblique surfaces are therefore advantageous.

The only disadvantage in the whole arrangement is that the air has not as free access to the upper aeroplane ac, in the triangular form of cell as in the quadrangular form, so that the aeroplane ac is not as efficient in the former construction as in the latter.

While theoretically the triangular cell is inferior in lifting power to Hargrave's four-sided rectangular cell, practically there is no substantial difference. So far as I can judge from observation in the field, kites constructed on the same general model as the Hargrave Box Kite, but with triangular cells instead of quadrangular, seem to fly as well as the ordinary Hargrave form, and at as high an angle.

Such kites are therefore superior, for they fly substantially as well, while at the same time they are stronger in construction, lighter in weight, and offer less head resistance to the wind.

Triangular cells also are admirably adapted for combination into a compound structure, in which the aeroplane surfaces do not interfere with one another. For example, three triangular-celled kites, tied together at the corners, form a compound cellular kite (Fig.6), which flies perfectly well.



PERSPECTIVE VIEW END VIEW

FIG. 6 — COMPOUND TRIANGULAR KITE

The weight of the compound kite is the sum of the weights of the three kites of which it is composed, and the total aeroplane surface is the sum of the surfaces of the three kites. The ratio of weight to surface therefore is the same in the larger compound kite as in the smaller constituent kites, considered individually.

It is obvious that in compound kites of this character the doubling of the longitudinal sticks where the corners of adjoining kites come together is an unnecessary feature of the combination, for it is easy to construct the compound kite so that one longitudinal stick shall be substituted for the duplicated sticks.

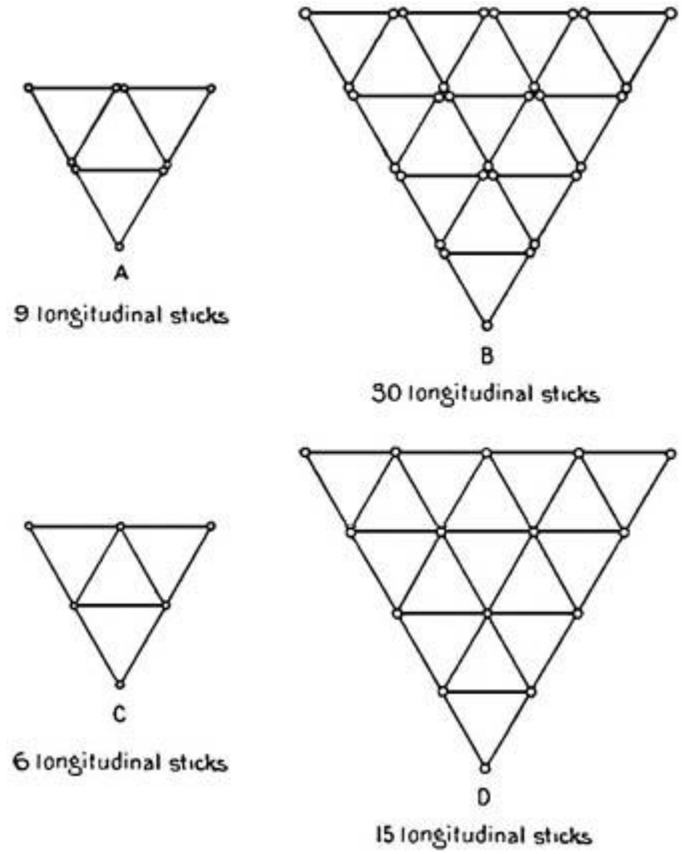


FIG. 7

For example: The compound kites A and B (Fig.7) may be constructed, as shown at C and D, with advantage, for the weight of the compound kite is thus reduced without loss of structural strength. In this case the weight of the compound kite is less than the sum of the weights of the component kites, while the surface remains the same.

If kites could only be successfully compounded in this way indefinitely we would have the curious result that the ratio of weight to surface would diminish with each increase in the size of the compound kite.

Unfortunately, however, the conditions of stable flight demand a considerable space between the front and rear sets of cells (see Fig.6); and if we increase the diameter of our compound structure without increasing the length of this space we injure the flying qualities of our kite.

But every increase of this space in the fore and aft direction involves a corresponding increase in the length of the empty framework required to span it, thus adding dead load to the kite and increasing the ratio of weight to surface.

While kites with triangular cells are strong in a transverse direction (from side to side), they are structurally weak in the longitudinal direction (fore and aft), for in this direction the kite frames are rectangular.

Each side of the kite A, for example (Fig.8), requires diagonal bracing of the character shown at B to prevent distortion under the action of the wind.

The necessary bracing, however, not being in the way of the wind, does not materially affect the head resistance of the kite, and is only disadvantageous by adding dead load, thus increasing the ratio of weight to surface.

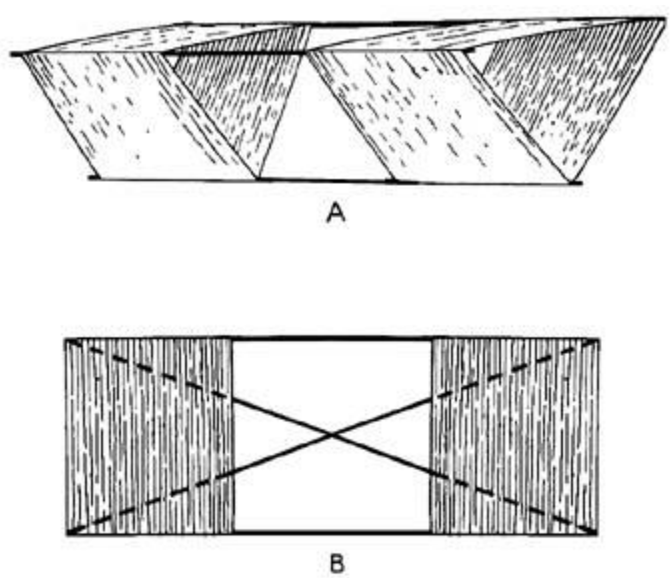


FIG. 8

THE TETRAHEDRAL CONSTRUCTION OF KITES

Passing over in silence multitudinous experiments in kite construction carried on in my Nova Scotia laboratory, I come to another conspicuous point of advance -- another milestone of progress - the adoption of the triangular construction *in every direction* (longitudinally as well as transversely); and the clear realization of the fundamental importance of the skeleton of a tetrahedron, especially the regular tetrahedron, as an element of the structure or framework of a kite or flying-machine.

Consider the case of an ordinary triangular cell A (Fig.9) whose cross-section is triangular laterally, but quadrangular longitudinally.

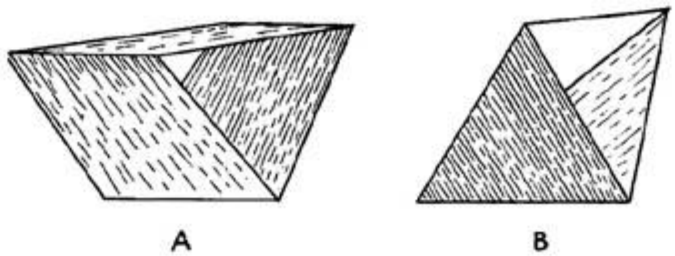


FIG. 9 — A. A TRIANGULAR CELL
B. A WINGED TETRAHEDRAL CELL

If now we make the longitudinal as well as transverse cross-sections triangular, we arrive at the form of cell shown at B, in which the framework forms the outline of a tetrahedron. In this case the aeroplanes are triangular, and the whole arrangement is strongly suggestive of a pair of birds' wings raised at an angle and connected together tip to tip by a cross-bar (see B, Fig.9; also drawings of winged tetrahedral cells in Fig.10).

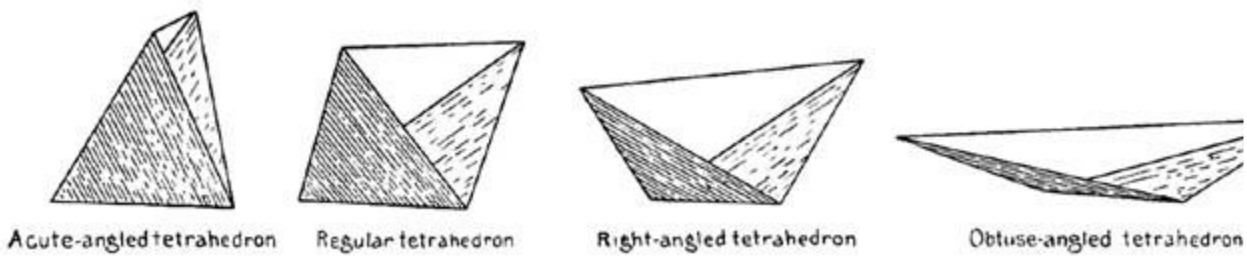


FIG. 10 — WINGED TETRAHEDRAL CELLS

A tetrahedron is a form of solid bounded by four triangular surfaces. In the regular tetrahedron the boundaries consist of four equilateral triangles and six equal edges. In the skeleton form the edges alone are represented, and the skeleton of a regular tetrahedron is produced by joining together six equal rods end to end so as to form four equilateral triangles.

Most of us no doubt are familiar with the common puzzle -- how to make four triangles with six matches. Give six matches to a friend and ask him to arrange them so as to form four complete equilateral triangles. The difficulty lies in the unconscious assumption of the experimenter that the four triangles should all be in the same plane. The moment he realizes that they need not be in the same plane the solution of the problem becomes easy. Place three matches on the table so as to form a triangle, and stand the other three up over this like the three legs of a tripod stand. The matches then form the skeleton of a regular tetrahedron (See Fig.11).

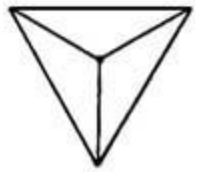


FIG. 11 — ONE-CELLED TETRAHEDRAL FRAME

A framework formed upon this model of six equal rods fastened together at the ends constitutes a tetrahedral cell possessing the qualities of strength and lightness in an extraordinary degree. It is not simply braced in two directions in space like a triangle, but in three directions like a solid. If I may coin a word, it possesses " three-dimensional " strength; not " two-dimensional " strength like a triangle, or "one-dimensional" strength like a rod.
It is the skeleton of a solid, not of a surface or a line.

It is astonishing how solid such a framework appears even when composed of very light and fragile material; and compound structures formed by fastening these tetrahedral frames together at the corners so as to form the skeleton of a regular tetrahedron on a larger scale possess equal solidity. Fig.12 shows a structure composed of four frames like Fig.11, and Fig.13 a structure of four frames like Fig.12.

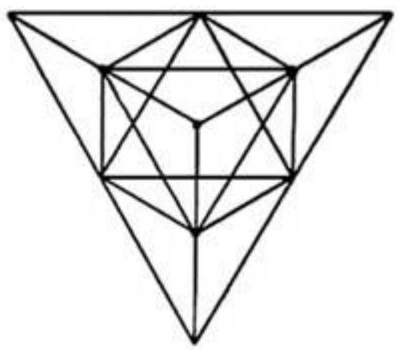


FIG. 12 —FOUR-CELLED TETRAHEDRAL FRAME

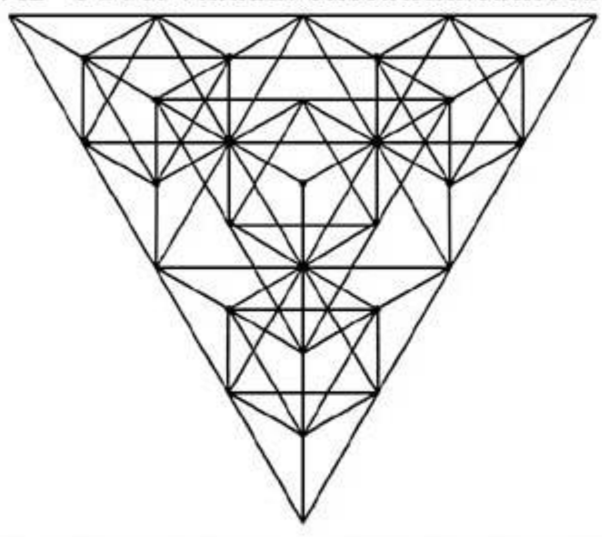


FIG. 13 — SIXTEEN-CELLED TETRAHEDRAL FRAME

When a tetrahedral frame is provided with aero-surfaces of silk or other material suitably arranged, it becomes a tetrahedral kite, or kite having the form of a tetrahedron.

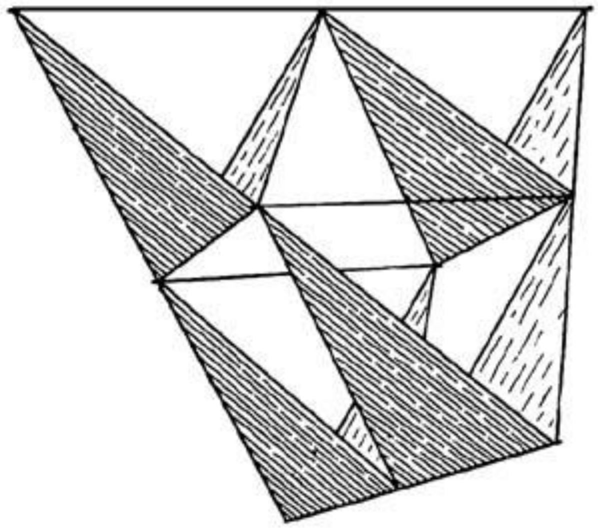


FIG. 14 — FOUR-CELLED TETRAHEDRAL KITE

The kite shown in Fig.14 is composed of four winged cells of the regular tetrahedron variety (see Fig. 10), connected together at the corners. Four kites like Fig.14 are combined in Fig.15, and four kites like Fig.15 in Fig.16 (at D).

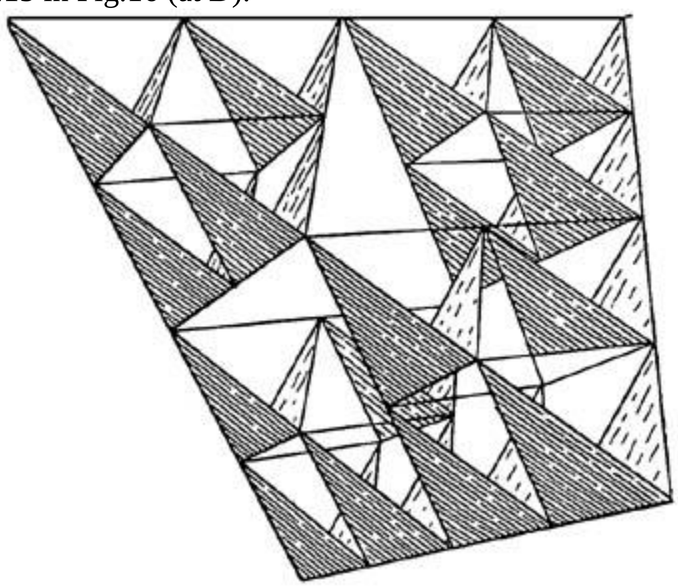


FIG. 15 — SIXTEEN-CELLED TETRAHEDRAL KITE

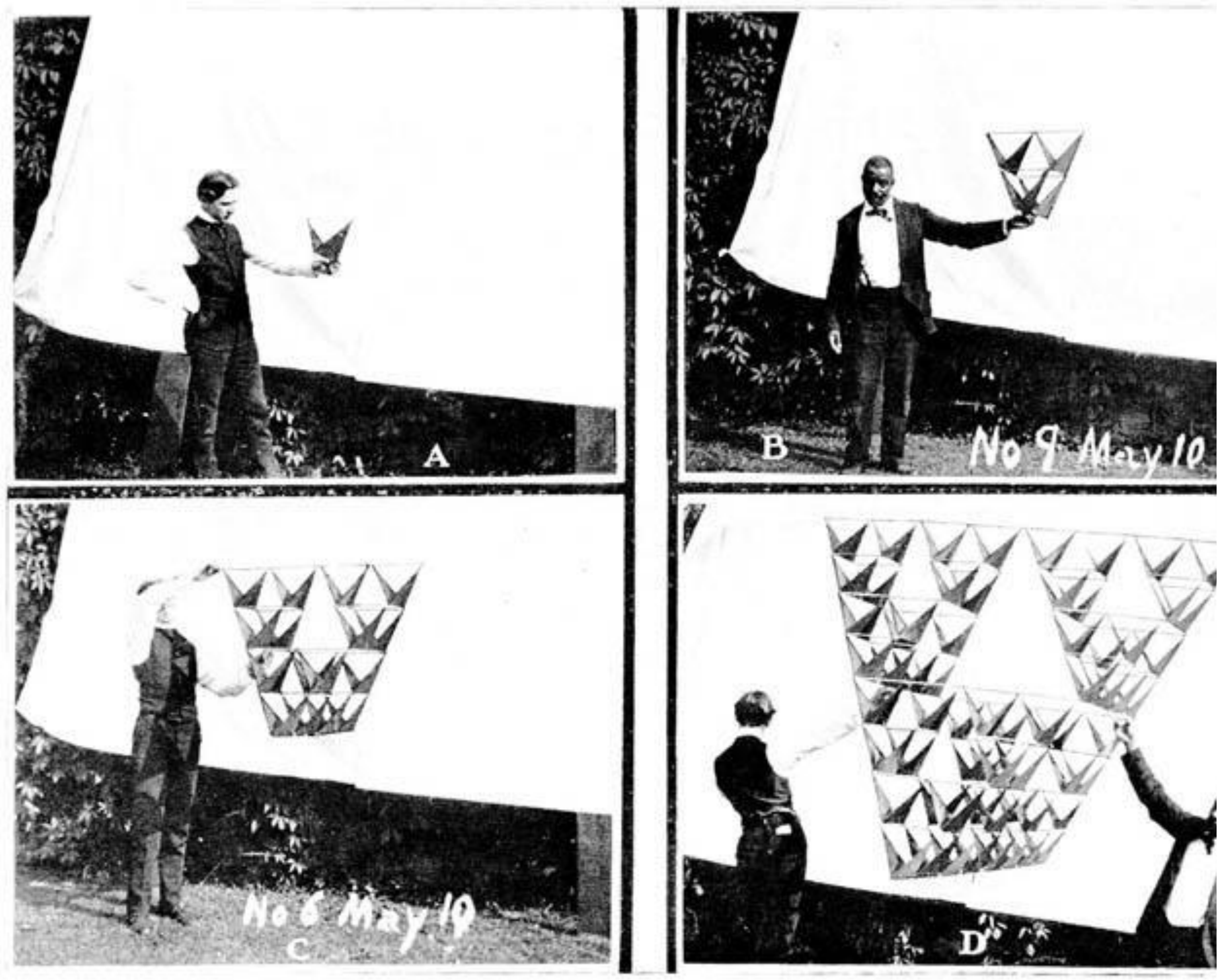


FIG. 16 — TETRAHEDRAL KITES

A. A WINGED TETRAHEDRAL CELL B. A 4-CELLED TETRAHEDRAL KITE
C. A 16-CELLED TETRAHEDRAL KITE D. A 64-CELLED TETRAHEDRAL KITE

Upon this mode of construction an empty space of octahedral form is left in the middle of the kite, which seems to have the same function as the space between the two cells of the Hargrave box kite. The tetrahedral kites that have the largest central spaces preserve their equilibrium best in the air.

The most convenient place for the attachment of the flying cord is the extreme point of the bow. If the cord is attached to points successively further back on the keel, the flying cord makes a greater and greater angle with the horizon, and the kite flies more nearly overhead; but it is not advisable to carry the point of attachment as far back as the middle of the keel. A good place for high flights is a point half-way between the bow and the middle of the keel.

In the tetrahedral kites shown in the plate (Fig.16) the compound structure has itself in each case the form of the regular tetrahedron, and there is no reason why this principle of combination should not be applied indefinitely so as to form still greater combinations.

The weight relatively to the wing-surface remains the same, however large the compound kite may be. The four-celled kite B, for example, weighs four times as much as one cell and has four times as much wing-surface, the 16-celled kite C has sixteen times as much weight and sixteen times as much-wing surface, and the 64-celled kite D has sixty-four times as much weight and sixty-four times as much wing-surface. The ratio of weight to surface, therefore, is the same for the larger kites as for the smaller.

This, at first sight, appears to be somewhat inconsistent with certain mathematical conclusions announced by Prof. Simon Newcomb in an article entitled "Is the Air-ship Coming," published in *Mclure's Magazine* for September, 1901 -- conclusions which led him to believe that "the construction of an aerial vehicle which could carry even a single man from place to place at pleasure requires the discovery of some new metal or some new force."

The process of reasoning by which Professor Newcomb arrived at this remarkable result is undoubtedly correct. His conclusion, however, is open to question, because he has drawn a general conclusion from restricted premises.

He says:

"Let us make two flying-machines exactly alike, only make one on double the scale of the other in all its dimensions. We all know that the volume, and therefore the weight, of two similar bodies are proportional to the cubes of their dimensions. The cube of two is eight: hence the large machine will have eight times the weight of the other. But surfaces are as the squares of the dimensions. The square of two is four. The heavier machine will therefore expose only four times the wing surface to the air, and so will have a distinct disadvantage in the ratio of efficiency to weight."

Professor Newcomb shows that where two flying-machines - or kites, for that matter - are exactly alike, only differing in the scale of their dimensions, the ratio of weight to supporting surface is greater in the larger than the smaller, increasing with each increase of dimensions. From which he concludes that if we make our structure large enough it will be too heavy to fly.

This is certainly true, so far as it goes and it accounts for my failure to make a giant kite that should lift a man - upon the model of the Hargrave box kite. When the kite was constructed with two cells, each about the size of a small room, it was found that it would take a hurricane to raise it into the air. The kite proved to be not only incompetent to carry a load equivalent to the weight of a man, but it could not even raise *itself* in an ordinary breeze in which smaller kites upon the same model flew perfectly well. I have no doubt that other investigators also have fallen into the error of supposing that large structures would necessarily be capable of flight, because exact models of them made upon a smaller scale, have demonstrated their ability to sustain themselves in the air. Professor Newcomb has certainly conferred a benefit upon investigators by so clearly pointing out the fallacious nature of this assumption.

But Professor Newcomb's results are probably only true when restricted to his premises. For models *exactly alike, only differing in the scale of their dimensions,* his conclusions are undoubtedly sound; but where large kites are formed by the multiplication of smaller kites into a cellular structure the results are very different. My own experiments with compound kites composed of triangular cells connected corner to corner have amply demonstrated the fact that the dimensions of such a kite may be increased to a very considerable extent without materially increasing the ratio of weight to supporting surface; and upon the tetrahedral plan (Fig. 16) the weight relatively to the wing-surface remains the same however large the compound kite may be.

The indefinite expansion of the triangular construction is limited by the fact that dead weight in the form of empty framework is necessary in the central space between the sets of cells (see Fig. 6), so that the necessary increase of this space when the dimensions of the compound kite are materially increased - in order to preserve the stability of the kite in the air --adds still more dead weight to the larger structures. Upon the tetrahedral plan illustrated in Figs. 14, 15, 16, no necessity exists for empty frameworks in the central spaces, for the mode of construction gives solidity without it.

Tetrahedral kites combine in a marked degree the qualities of strength, lightness, and steady flight; but further experiments are required before deciding that this form is the best for a kite, or that winged cells without horizontal aeroplanes constitute the best arrangement of aero-surfaces.

The tetrahedral principle enables us to construct out of light materials solid frameworks of almost any desired form, and the resulting structures are admirably adapted for the support of aero-surfaces of any desired kind, size, or shape (aeroplanes or aerocurves, etc. large or small).

In further illustration of the tetrahedral principle as applied to kite construction, I show in Fig.17 a photograph of a kite which is not itself tetrahedral in form, but the framework of which is built up of tetrahedral cells.

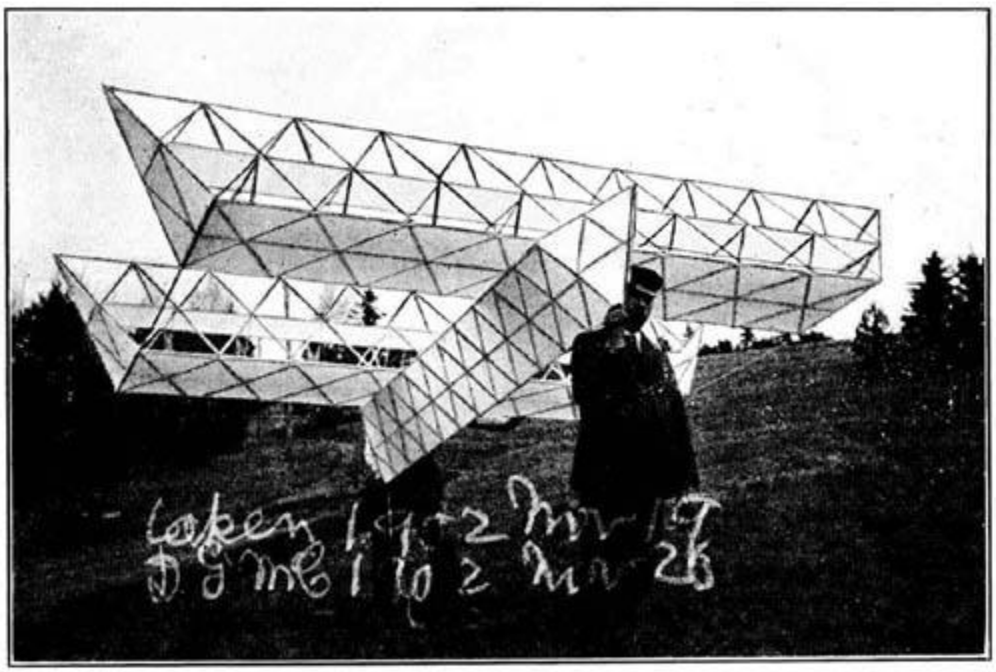


FIG. 17 — THE AERODOME KITE

This kite, although very different in construction and appearance from the Aerodrome of Professor Langley, which I saw in successful flight over the Potomac a few years ago, has yet a suggestiveness of the Aerodrome about it, and it was indeed Professor Langley's apparatus that led me to the conception of this form.

The wing surfaces consist of horizontal aeroplanes, with oblique steadying surfaces at the extremities. The body of the machine has the form of a boat, and the superstructure forming the support for the aeroplanes extends across the boat on either side at two points near the bow and stern. The aeroplane surfaces form substantially two pairs of wings, arranged dragon-fly fashion. The whole framework of the boat and wings is formed of tetrahedral cells, having the form of the regular tetrahedron, with the exception of the diagonal bracing at the bottom of the superstructure; and the kite turns out to be strong, light, and a steady flyer.

I have flown this kite in a calm by attaching the cord - in this case a Manila rope- to a galloping horse. Fig.18 shows a photograph of the kite just rising in the air. With the horse in the foreground, but the connecting rope does not show.

FIG. 18 — THE AERODROME KITE JUST RISING INTO THE AIR WHEN PULLED BY A HORSE

Figure 19 is a photograph of the kite at its point of greatest elevation, but the horse does not appear in the picture. Upon releasing the rope the kite descended so gently that no damage was done to the apparatus lip contact with the ground.

FIG. 19 — AERODOME KITE IN THE AIR

Figure 20 shows a modified form of the same kite, in which, in addition to the central boat, there were two side floats, thus adapting the whole structure to float upon water without upsetting.

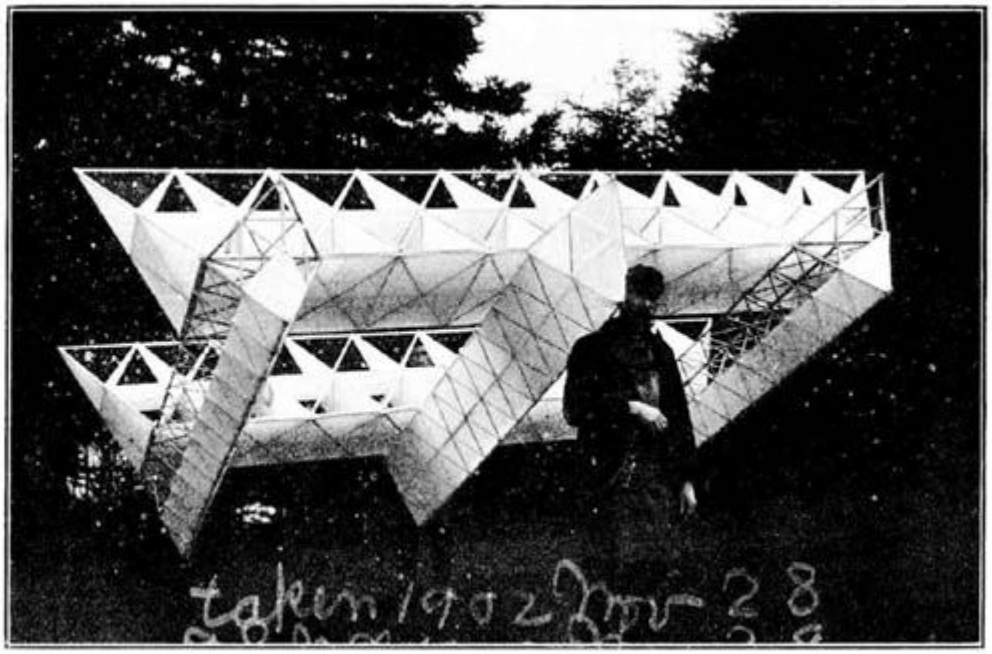


FIG. 20 — FLOATING KITE

An attempt which almost ended disastrously, was made to fly this kite in a good sailing breeze, but a squall struck it before it was let go. The kite went up, lifting the two men who held it off their feet. Of course they let go instantly, and the kite rose steadily in the air until the flying cord (a Manila rope 3/8 inch diameter) made an angle with the horizon of about 45 degree when the rope snapped under the strain.

Tremendous oscillations of a pitching character ensued; but the kite was at such an elevation when the accident happened, that the oscillations had time to die down before the kite reached the ground, when it landed safely upon even keel in an adjoining field and was found to be quite uninjured by its rough experience.

Kites of this type have a much greater lifting power than one would at first sight suppose. The natural assumption is that the winged superstructure alone supports the kite in the air, and that the boat body and floats represent mere dead-load and head resistance.

But this is far from being the case. Boat-shaped bodies having a V-shaped cross-section are themselves capable of flight and expose considerable surface to the wind. I have successfully flown a boat of this kind as a kite without any superstructure whatever, and although it did not fly well, it certainly supported itself in the air, thus demonstrating the fact that the boat surface is an element of support in compound structures like those shown in Fig.17 and 20.

Of course the use of a tetrahedral cell is not limited to the construction of a framework for kites and flying - machines. It is applicable to any kind of structure whatever in which it is desirable to combine the qualities of strength and lightness. Just as we can build houses of all kinds out of bricks, so we can build structures of all sorts out of tetrahedral frames, and the structures can be so formed as to possess the same qualities of strength and lightness which are characteristic of the individual cells. I have already built a house, a framework for a giant wind-break, three or four boats, as well as several forms of kites, out of these elements.

It is not my object in this communication to describe the experiments that have been made in my Nova Scotia laboratory, but simply to bring to your attention the importance of the tetrahedral principle in kite construction.

VI. Unit Resources

Annotated Bibliography

DeMey, J. (2013, April 11). Impossible Kite. Retrieved July 1, 2015, from http://www.anopticalillusion.com/2013/04/impossible-kite-by-jos-de-mey/

Jos DeMey depicts an optical illusion of a three dimensional kite from an aerial view. This painting helps students to explore different aspects of geometric concepts.

Dunbar, B. (Ed.). (2014, January 31). Beginning Engineering, Science and Technology. Retrieved June 1, 2015, from http://www.nasa.gov/audience/foreducators/best/edp.html#.VcRY33FViko

This website provides a video series on the Engineering design process. NASA provides a valuable resource for both teachers and students as it guides the viewer through the steps of the design process while introducing different methods and approaches to solving design problems.

Graham Bell, A. (1903, June 6). Tetrahedral Principle in Kite Structure. *National* Geographic. Retrieved from: http://britton.disted.camosun.bc.ca/bell/bell.htm

Bell describes the construction of varying tetrahedral kites and their aerodynamics which also includes various diagrams and pictures. This article is a valuable resource to both the teacher and student as they explore the mathematics and science behind kite construction and flight.

Hall, N. (Ed.). (2015, May 5). Kites. Retrieved May 7, 2015, from https://www.grc.nasa.gov/www/k-12/airplane/kite1.html

NASA compiled valuable information on the history, types, and aerodynamics of kites with diagrams and explanations. This website is valuable for both the student and teacher in gaining a general understanding of the history of kites and the forces on a kite.

Peak, H. & Morrison, I. (2012). Retrieved July 1, 2015, from http://www.morison.info/littleshiningman.html

An inspirational video of a sculpture that takes flight based on the tetra kites of Alexander Graham Bell. This video helps students visualize the flight of an enormous tetra kite that is both strong and lightweight, one structure made from more than 23,000 individual components, and completely assembled by hand over 16 months.

The Engineering Design Process. (2015). Retrieved June 1, 2015, from http://www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml#theengineeringdesignprocess

Science Buddies is a non-profit organization that provides students, teachers, and parents resources for project ideas, learning tools to enhance 21st century skills, and access to scientific research and scientists. This website is valuable to both teachers and students to gain a better understanding of the engineering process and how science and math can be relevant in a student's life.

What is Soaring – Learning to Fly Gliders. (2013). Retrieved May 1, 2015, from http://www.ssa.org/LearningToFlyGliders

This website is dedicated to the sport of soaring and has compiled information about how, when, and where to soar along with safety and racing events. This website will give the teacher a realistic understanding of flight that can be applied to the kite unit.