DOCUMENT RESUME

ED 458 131	SE 065 302
TITLE	Geometry and Algebra: Glow with the Flow. NASA Connect: Program 2 in the 2000-2001 Series.
INSTITUTION	National Aeronautics and Space Administration, Hampton, VA. Langley Research Center.
REPORT NO	EG-2000-10-17-LaRC
PUB DATE	2000-00-00
NOTE	20p.; Accompanying videotape not available from ERIC. For other documents in series, see SE 065 301-305.
PUB TYPE	Guides - Classroom - Teacher (052)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Aerospace Technology; *Algebra; Force; *Geometry; Intermediate Grades; Junior High Schools; *Lesson Plans; Mathematics Education; Models; *Motion; Science Activities; Science and Society; Science Instruction; *Space Sciences

ABSTRACT

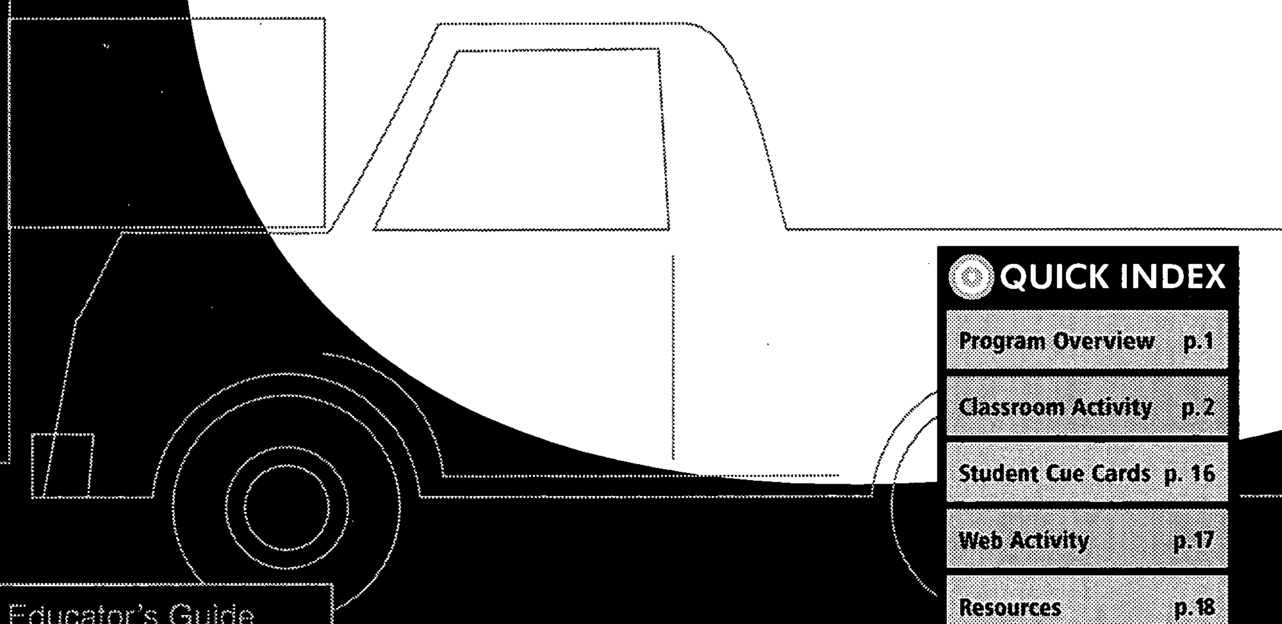
This teaching unit is designed to help students in grades 5 to 8 explore the concepts of geometry and algebra in the context of the force of drag. The units in the series have been developed to enhance and enrich mathematics, science, and technology education and to accommodate different teaching and learning styles. Each unit consists of background notes for the teacher, a list of teacher resources, and two activities, one of which is Web-based, complete with blackline masters. Also included are suggestions for extensions to the problems and their relationships to national mathematics, science, and technology standards. In this activity, students learn about the force of drag and how National Aeronautics and Space Administration (NASA) engineers use models and glowing paints to see how air flows over vehicles in a wind tunnel. (MM)

NASA CONNECT

Program 2 in the 2000-2001 Series

Geometry and Algebra:

Glow with the Flow



Educator's Guide

Teachers & Students | Grades 5-8

Publication Number EG-2000-10-17-LaRC

PROGRAM OVERVIEW

SUMMARY AND OBJECTIVES

In *Geometry and Algebra: Glow with the Flow*, students will learn about the force of drag and how NASA engineers use models and glowing paints to see how air flows over vehicles in a wind tunnel. Students will also discover how the blended wing body (BWB), a concept super jumbo jet that resembles a flying wing, will affect air travelers of the future. Students will observe NASA engineers using geometry and algebra when they measure and design models to be tested in wind tunnels. By conducting classroom and on-line activities, students will make connections between NASA research and the mathematics, science, and technology they learn in their classroom.

INTERACTIVE ACTIVITIES

Questions are posed throughout the video by Norbert, the animated co-host of NASA CONNECT. These questions direct the instruction and encourage students to think about the concepts being presented. An icon appears in the video to suggest to teachers an appropriate place to pause the video and discuss the answers to the questions. Students record their answers on the Student Cue Cards (p. 16).

"What a Drag!," the hands-on classroom activity is teacher-created and is aligned with the national mathematics, science, and technology standards. Students will learn how shape and surface area affect drag. Through experimenting and predicting, students use measurement, formulas, and graphing to test their findings just like NASA researchers.

MAX, or Mars Airborne eXplorer, the on-line activity, invites students to manipulate lift, drag, thrust, and weight to build and fly an airplane that will successfully drop life-seeking probes on Mars' surface. MAX is located in Norbert's lab at **http://connect.larc.nasa.gov/flow/lab.html**

RESOURCES

Teacher and student resources (p.18) support, enhance, and extend the NASA CONNECT program. Books, periodicals, pamphlets, and web sites provide teachers and students with background information and extensions. In addition to the resources listed in this lesson guide, the NASA CONNECT web site, **http://connect.larc.nasa.gov**, offers on-line resources for teachers, students, and parents. Teachers who would like to to get the most from the NASA CONNECT web site can access Norbert's Lab and receive assistance from the Lab Manager.

THE CLASSROOM ACTIVITY

BACKGROUND

The "What a Drag!" activity is designed to visually simulate the research done by NASA Langley Research Center's engineers working on flow visualization and the blended wing body (BWB). The BWB is a new aircraft design that NASA and Boeing are studying. This 160 ft long, 40 ft high commerical transport will have a 247-ft wingspan and carry up to 500 passengers. Powered by three turbofan engines, the BWB will have a range of 7,000 nautical miles and a cruising speed of Mach 0.85. Preliminary estimates by engineers at the NASA Langley Research Center indicate that the BWB design could reduce direct operating costs for airlines by as much as 15% and fuel consumption by 25%. The unique aerodynamic shape of the structure and the new lightweight materials used for construction will result in lower fuel consumption and operating costs. In addition to commercial transports, the BWB holds promise as a potential long-range troop transport and refueling tanker for the military.

Flow visualization is an important tool used in fluid dynamics research. Fluid dynamics is the branch of applied science that is concerned with the movement of gases and liquids. Because "seeing is believing" and most of the fluids and their motions are invisible to human eyes, numerous techniques have been developed over the years to visualize their movement. These techniques provide an "eye-catching" way for engineers to visualize the motions of fluids and gases and their interactions with the surroundings before proceeding with detailed measurement and mathematical modeling. Flow visualization has been used extensively in the fields of engineering, physics, medical science, meteorology, oceanography and aerodynamics. In addition, there is a great deal of aesthetic pleasure to be gained from seeing the results of flow visualization. This aspect of flow visualization touches the general public: we are all familiar with the aspect of clouds in the sky and the swirling patterns to be seen in rivers and seas.

Students will work in groups of three to perform and analyze data for three separate experiments. By experimenting and predicting, students use measurement, formulas, and graphing to test their findings. First, the students will construct a drag apparatus and three-dimensional shapes to test for drag. The objective of this experiment or demonstration is to discern which shape is the most aerodynamic (has the least amount of drag). The students will then conduct an experiment by using two plastic cars, a control car, an experimental car, and disks of various sizes to determine a correlation between surface area and drag. In the final experiment or demonstration, students will combine their findings about shape and surface area to determine the most aerodynamic shape (the shape with the least amount of drag).

THE BASICS OF FLIGHT

Do you ever wonder how an airplane flies? There are four basic forces acting on an airplane (figure 1).

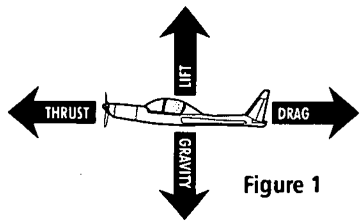


Figure 1

The weight (force due to gravity) pulls down on the plane and opposes the lift created by air flowing over the wing. Thrust, which propels the airplane forward, is generated by the propeller and opposes drag caused by air resistance to the frontal area of the airplane. For an airplane to take off, thrust must overcome drag and lift must overcome the weight of the airplane. In level flight, at constant speed, thrust equals drag and lift equals weight. When an airplane lands, thrust must be reduced below the level of drag and lift must be reduced below the weight of the airplane.

What causes lift in an airplane? There are two current interpretations to explain lift of an airplane. These two interpretations have been debated for many years, thus they are both presented to you. The first explanation is the pro-Newton, which states that wings are forced upward because they are tilted and deflect air downwards. Both the upper and lower surfaces of the wing act to deflect the air. The upper surface deflects air downwards because the airflow "sticks" to the wing surface and follows the tilted wing. This interpretation is called the "Coanda effect."

The second explanation is the pro-Bernoulli or Airfoil-Shape, which states that wings do not deflect air; instead they are pushed upwards. Because air is a continuum, when it is divided at the leading edge of a wing, it must rejoin at the trailing edge. The curvature of the "airfoil" shape causes the air to flow faster over the upper surface than over the lower surface, which creates a lower pressure above the wing than below the wing (figure 2).

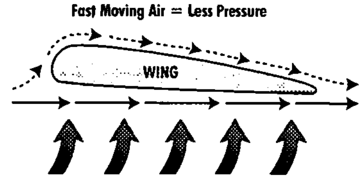


Figure 2

What causes drag? Drag is the force that opposes all motion in the atmosphere. Therefore, air resistance causes drag. How many times have you stuck your hand out the window of a moving car? If you tilt your hand slightly upward, the impact of the air will cause your hand to rise. But more importantly, you will encounter the air resistance and experience drag. The drag force will push your hand backwards. With airplanes, drag forces consist of a number of components. The total drag on an airplane can be broken up into two major divisions, induced drag and parasite drag. Parasite drag consists of skin-friction drag and form drag.

For this activity our focus is to investigate form drag, which is resistance to the smooth flow of air. The shape of an object may create turbulence, which retards the forward movement. Streamlining the object will help eliminate form drag (figure 3).

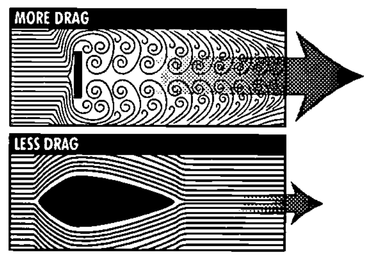


Figure 3

NATIONAL STANDARDS

MATHEMATICS STANDARDS

- Use computational tools and strategies fluently and estimate appropriately.
- Understand various types of patterns and functional relationships.
- Use symbolic forms to represent and analyze mathematical situations and structures.
- Use mathematical models and analyze change in both real and abstract contexts.
- Analyze characteristics and properties of two- and three-dimensional geometric objects.
- Select and use different representational systems, including coordinate geometry and graph theory.
- Use visualization and spatial reasoning to solve problems both within and outside of mathematics.
- Understand attributes, units, and systems of measurement.
- Apply a variety of techniques, tools, and formulas for determining measurements.
- Pose questions and collect, organize, and represent data to answer those questions.
- Interpret data by using methods of exploratory data and analysis.
- Develop and evaluate inferences, predictions, and arguments that are based on data.
- Develop a disposition to formulate, represent, abstract, and generalize in situations within and outside mathematics.
- Monitor and reflect on their mathematical thinking in solving problems.
- Organize and consolidate mathematical thinking to communicate with others.
- Extend mathematical knowledge by considering the thinking and strategies of others.
- Recognize, use, and learn about mathematics in contexts outside of mathematics.
- Create and use representations to organize, record, and communicate mathematical ideas.
- Use representations to model and interpret physical, social, and mathematical phenomena.

SCIENCE STANDARDS

- Science as Inquiry
- Physical Science
- Motion and Forces
- Transfer of Energy
- Science and Technology
- Abilities of technological design.
- Understanding about science and technology.
- History and Nature of Science

TECHNOLOGY STANDARDS

- Proficient use of technology.
- Develop positive attitude toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.
- Use technology to enhance learning, increase productivity, and promote creativity.
- Use technology tools to process data and report results.
- Use technology resources for solving problems and making informed decisions.

INSTRUCTIONAL OBJECTIVES

Students will be able to do the following:

- determine dimensions of various geometric figures by using appropriate metric measures.
- calculate the area of various geometric figures by using the appropriate metric measures and the appropriate formulas.
- calculate the frontal surface area of various geometric objects by using the appropriate formulas.
- compare the effect of drag on different geometric objects.
- determine the surface area of circular disks.
- determine the distance (in drag units) as it relates to surface area.
- graph the results of the trials as frontal surface area versus distance traveled.
- analyze the data and determine a correlation.
- predict which object has the least amount of drag.
- test their predictions.

VOCABULARY

aerodynamics - the dynamics of gases, especially of atmospheric interactions with moving objects
area - space inside a closed figure
cone - a three-dimensional object with a circular base and one vertex
correlation - a relation in which the values of the variables increase or decrease together, or the value of one variable that increases as the value of the other variable decreases
cube - a solid figure with six congruent square faces
drag - force of resistance exerted on an object by a gas or liquid
frontal surface Area (defined for activity) - the sum of the areas of the lateral faces of an object that interferes with the air flow
lift - the surface flow of air generated around the wings of the plane that enables the plane to lift off the ground and to stay in flight
mass - an object's quantity of matter
mean - the average of all numbers in a data set
polyhedron - a solid bounded on all sides by polygons (e.g., cones, cubes, pyramids)
proportion - a statement of equality between two or more ratios
slant height - the length of a segment extending from the vertex of the pyramid or cone to the edge of the base
square-based pyramid - a solid figure that has a square for a base and triangular sides which share a common vertex
tetrahedron - a solid figure that has a triangle for a base and triangular sides which share a common vertex
thrust - the force of an engine that pushes a plane forward (the opposite of drag)
vehicle - any device for carrying passengers, goods, or equipment.
vertex (defined for activity) - a point on a polyhedron common to three or more sides
weight - a measure of force determined by the amount of gravity acting upon a mass

PREPARING FOR THE ACTIVITY

MATERIALS

DRAG STAND (per group)
duct tape
scissors
flexible drinking **straw**
block of heavy **foam** 10 cm X 10 cm X 15 cm
30-cm wooden **skewer**
metric **ruler**
box fan with three speeds
extension cord (optional)

DRAG ARM (per group)
duct tape
scissors
2 flexible drinking **straws**
wooden **ruler** (with holes)

TEST OBJECTS (per group)
shape patterns (p. 13-14)
scissors
clear **tape**
glue (optional)

TEST TRACK (per class)
box fan with three speeds
2 **ring stands** and 2 **clamps**
3.5 meters of kite **string**
2 truck or van-type **plastic cars** approximately 24 cm (10 in.) long with wheels that turn freely
3 **meter sticks**
scissors
duct tape
small block of heavy **foam** approximately 5 cm by 3 cm that fits on the front of your vehicle
4 meters of **bulletin board paper**
2 **pulleys** - approximately 1/2 in. to 2 in. in diameter

TEST DISKS (per group)
set of **disk patterns** (p. 15)
scissors
cardboard for patterns
pencil
data chart

The formulas needed for this activity are listed below:

Frontal Surface Area:
Cone: πrl
r = radius
l = slant height

Cube: s2
s = side

Pyramid: 2bh
b = base
h = height

Tetrahedron: (3/2)bh
b = base
h = height

TIME

Construction of drag assembly, testing of objects, and analysis of data . . . .45 min
Assembly of test vehicles, test track, testing of disks, and analysis of data . .45 min

ADVANCE PREPARATION

Depending on the abilities of the students, the teacher may wish to construct the drag stand and geometric shapes in advance. The teacher may wish to perform Activity A and Activity C as demonstrations. For Activity C, construct the tetrahedrons in advance. Using the tetrahedron figure on page 13 as a template, increase and decrease the size of the tetrahedron by using a photocopier. Prepare four different sizes to test.

FOCUS QUESTIONS

1. What are some factors that engineers consider in designing transportation vehicles (e.g., cars, trucks, airplanes, boats)?
2. Why are these factors important?
3. Of all the factors considered, which one do you think would be the most important? Why?

ACTIVITY A: TESTING SHAPES

STEP 1: CONSTRUCT THE DRAG STAND AND DRAG ARM

A. DRAG STAND ASSEMBLY (one per class)

1. Insert the wooden skewer 5 cm into the center of the foam block so that the measurement from the top of the wooden skewer to the bottom of the foam, where inserted, is 15 cm.
2. Measure and cut a 10 cm X 1 cm piece of duct tape.
3. Wrap the tape around the straw 2 cm from one end, making sure the tape is evenly wrapped and forms a level surface.
4. Slide the straw over the wooden skewer until it makes contact with the foam block (figure 4).
5. Place the box fan on a table or other flat, smooth surface and plug in.
6. Loop a piece of duct tape to make double-sided tape. Attach the duct tape to the bottom of the foam block.
7. Measure 1 meter from the front center of the box fan and place drag stand at that point, making sure it is secured to the surface (figure 5).

Note: Testing apparatus should be at least 3 meters from any wall to minimize turbulence.

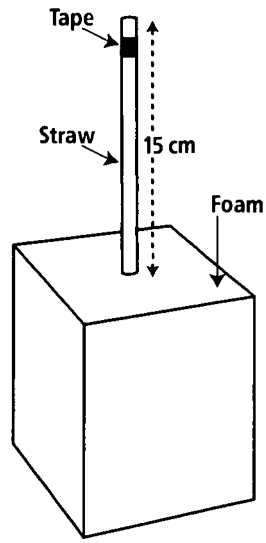


Figure 4: Drag Stand

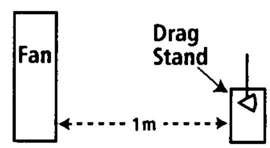


Figure 5

B. DRAG ARM ASSEMBLY

1. Insert a flexible straw into the outer holes of a wooden ruler an equal distance from the center hole (pivot point).
2. Secure straws to the ruler by placing two small pieces of duct tape around the top of the straw (figure 6).

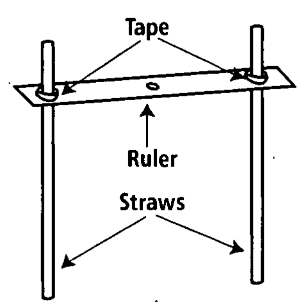


Figure 6: Drag Arm

STEP 2: CONSTRUCT POLYHEDRONS

1. Cut out the Shape Patterns (p. 13-14), bend on the dotted lines, and tape the edges together (cone, cube, tetrahedron, and pyramid).

QUESTIONS

1. What is drag?
2. How do engineers test for drag?
3. How would shape affect drag?
4. What are some direct and indirect negative effects of drag on a vehicle?

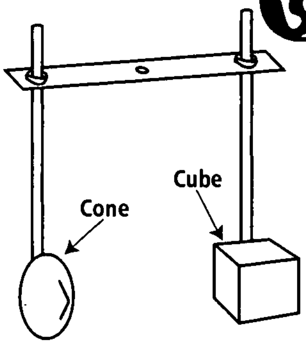


Figure 7: Drag Arm

STEP 3: CONDUCT THE EXPERIMENT

1. Use the formulas given in the chart to calculate the frontal surface area for each shape and record on Student Data Sheet A (p.11).
2. Use the shapes (p. 13-14), beginning with the cone and the cube. Use transparent tape to attach one shape to the bottom of each straw. Position shapes as shown in figure 7.
3. Place the drag arm onto the drag stand by placing the ruler over the straw on the drag stand (figure 8).
4. Turn the fan on LOW speed.
5. Observe and note which shape moves closer to the fan. This shape will be the one that has the least amount of drag.
6. Record on Student Data Sheet A (p.11).
7. Repeat steps 2-6, following the combination of shapes given on Student Data Sheet A (p. 11).

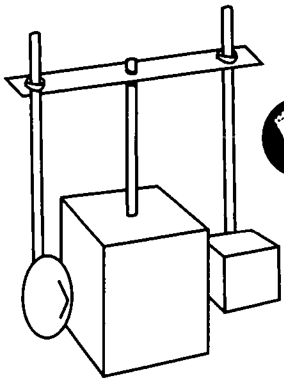


Figure 8

STEP 4: ANALYZE THE DATA

1. Using the data from Student Data Sheet A (p. 11), which shape had the least amount of drag (the shape that appears in your chart the most often)?

CONCLUSION

2. Does shape affect drag? Why or why not?
3. What other variables could have affected the outcome of the experiment?

QUESTIONS

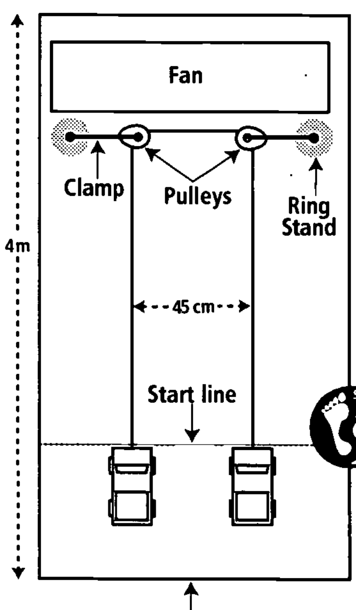
1. How would changing the frontal surface area affect drag?

ACTIVITY B: TESTING SURFACE AREA

STEP 1: CONSTRUCT THE DISKS

Note: Students should work in groups of three to construct the materials and conduct the trials.

1. Select 5 circles from the disk pattern templates provided (p. 15).
2. Trace and cut out the circles onto the cardboard to create test disks; label each disk as it is on the pattern.
3. Predict the area of test disk one.
4. Record prediction on Student Data Sheet B (p. 12).
5. Calculate the actual area of test disk one and record answer on Student Data Sheet B (p. 12).
6. Repeat steps 2-5 for each test disk.



Bulletin Board Paper
Figure 9

STEP 2: CONSTRUCT DRAG TRACK

1. Measure and cut 4 meters of bulletin board paper and place on a clean, smooth flat surface (floor).
2. Place the box fan at one end of the bulletin board paper.
3. Clamp a pulley horizontally on each ring stand near the bottom of the stand.
4. Place one ring stand on each side of the box fan next to the front of the fan, with pulleys pointing toward the middle of the fan. The distance apart will vary according to your fan and pulleys, but the suggested distance is about 45 cm (15 in.) (figure 9).

STEP 3: PREPARE THE TEST VEHICLE AND TEST TRACK

1. Cut a piece of the heavy foam into a small block shape, large enough to rest on top of the hood of one of your vehicles. (The foam block will be used to keep the disk perpendicular during testing to keep results uniform.)
2. Tape the foam block to the top of the hood of the test vehicle so that it is flush with where the disk will be placed on the front of the vehicle (figure 10).
3. Measure and cut a piece of duct tape approximately 20 cm long. Loop the tape around to form double-sided tape.
4. Place the tape on the front of the test vehicle so you can attach the disk.
5. Measure and cut the kite string 3.5 meters long.
6. Tie or tape one end of the kite string to the center front of one vehicle.
7. Thread the string through each pulley and attach the other end of the kite string to the center front of the control vehicle (figure 11) in the same location as first vehicle.
8. Adjust the pulley height so that the kite string is even with the height where it was tied to the vehicle. The string will be parallel to the floor and the same height for both vehicles (figure 12).
9. Pull and adjust the vehicles so kite string is taut.
10. Align the vehicles so that the front end of each vehicle is the same distance from the fan. Mark this position as your start line by drawing a horizontal line on the bulletin board paper perpendicular to the outer edge (figure 9, p. 8).

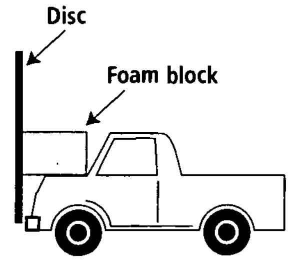


Figure 10: Test Vehicle

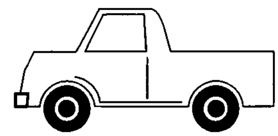


Figure 11: Control Vehicle

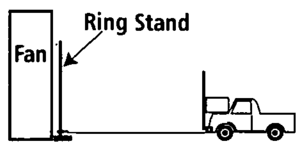


Figure 12

STEP 4: CONDUCTING THE TEST

1. Choose any disk and place it on the front of the test vehicle, perpendicular to the floor.
2. Align the vehicles with the start line, making sure kite string is in the pulley system and taut.
3. Predict the distance in drag units (1 cm = 1 drag unit) that the test vehicle will travel when the fan is turned on. This distance will be recorded in drag units, with 1 cm equal to 1 drag unit. Record predictions on Student Data Sheet B (p. 12).
4. Turn the fan on high speed for approximately 10 seconds and observe the movement of the vehicles. *Note: This time is only a suggested time. Time will depend on your fan speed and test vehicles.*
5. Measure the distance that the test vehicle moved backward. Record the drag units on Student Data Sheet B (p. 12).
6. Calculate the difference between the predicted and the actual drag units and record your answer. How did you do?
7. Repeat steps 1-7 for each of the other test disks.

STEP 5: ANALYZE THE DATA

1. When all tests are completed, create a class chart of the data from each group.
2. Find an average of all data reported for each disk.
3. Construct a graph and graph the data by using the class average for each disk.

STEP 6: CONCLUSIONS

1. How did area affect the drag units?
2. If the area affected drag units, was there a correlation?
3. Discuss the relationship shown by the graph. Is it positive? Is it linear?
4. What types of everyday objects in your environment would be affected by drag?

ACTIVITY C: DEMOSTRATION

QUESTIONS

1. How does the combination of surface area and shape affect drag?
2. What would be the most effective combination when you combine the shape and the surface area?

STEP 1: CONDUCT DEMONSTRATION

1. Construct the four additional tetrahedron shapes (see advanced preparation, p. 7).
2. Place all shapes on the table.
3. Based on the conclusions from activities A and B, ask the students which shape and size they think is the most aerodynamic (based on the least amount of drag on frontal surface area and shape).
4. Ask students to explain why they chose that shape.
5. Ask students what statement they can make about the factors that affect drag (based on analysis of their data).

STEP 2: CONCLUSIONS

Test the students' hypothesis for the shape they chose. Using what they learned from the two experiments, they should know that the tetrahedron was the most aerodynamic and that an object with the least amount of frontal surface area will have the least amount of drag. Combining those two ideas, the students should choose the smallest tetrahedron.

EXTENSIONS

ACTIVITY A - TESTING THE SHAPES

1. If you were designing a vehicle for NASA, which shape would be the most aerodynamic? Draw a picture of your vehicle and justify your design.
2. Why would NASA want vehicles that are aerodynamically designed?
3. How would the shape of an object be affected by drag in space?

ACTIVITY B - TESTING THE DISKS

1. Using a graphing calculator, find the equation of the line.
2. Find the slope of the line.
3. Predict drag units for other surface areas.
4. Use different sized vehicles and disks.
6. Test geometric objects for drag.

STUDENT DATA SHEETS

DATA SHEET A

Calculate and record the frontal surface area for each shape.

CALCULATION AREA:

SHAPE	FORMULA	FRONTAL SURFACE AREA
Cone	πrl	
Cube	s^2	
Pyramid	2bh	
Tetrahedron	(3/2)bh	

PRE-ACTIVITY QUESTIONS

1. What are the total possible combinations among the four shapes?____________
2. Considering the objects in the chart, what is the probability that any one object (e.g., cone) will have the least amount of drag?

____

Test the cone against each shape and record the name of the shape that had the least amount of drag. Repeat the test with the cube, pyramid, and tetrahedron. Note which shape appears the most frequently in the matrix.

SHAPE	CONE	CUBE	PYRAMID	TETRAHEDRON
Cone				
Cube				
Pyramid				
Tetrahedron				

CONCLUSION

1. Which shape had the least amount of drag?____________________
2. Why did that shape have the least drag?____________________
3. How does shape affect drag?____________________________
4. What other variables could have affected the outcome of the experiment?______

DATA SHEET B

CALCULATION AREA:

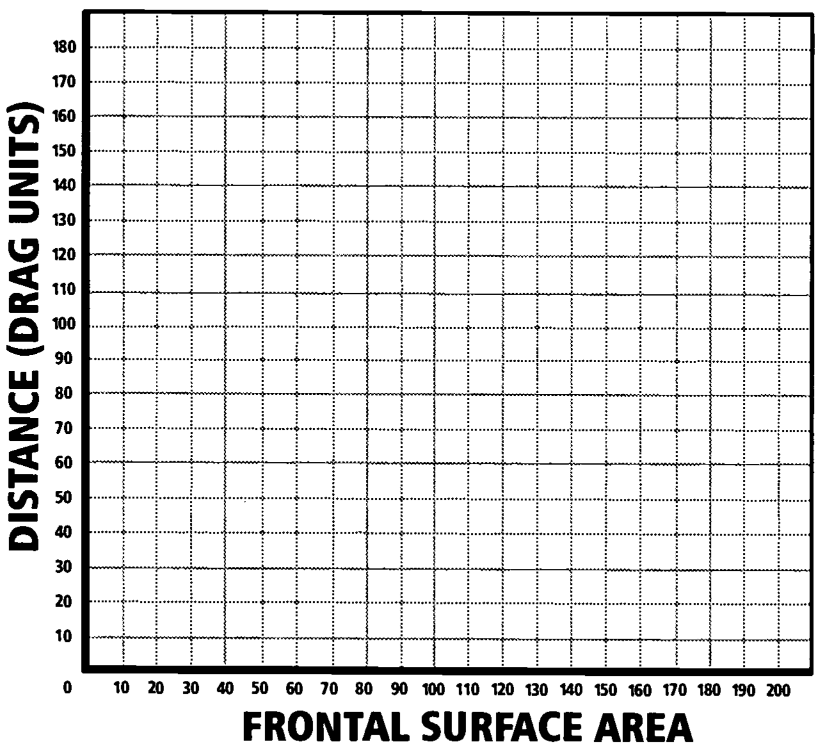
A. Predict the area for disk 1 and record your response. Measure, calculate, and record actual area. Find the difference between predicted and actual area and record the answer. Repeat with each test disk.

B. Predict the number of drag units that test disk 1 will create and record the number. Test and find the actual distance and record. Find the difference between predicted and actual distance and record the answer. Repeat for each additional test disk.

	FRONTAL SURFACE AREA			DISTANCE		
DISK	PREDICTED	ACTUAL	DIFFERENCE	PREDICTED	ACTUAL	DIFFERENCE
1						
2						
3						
4						
5						

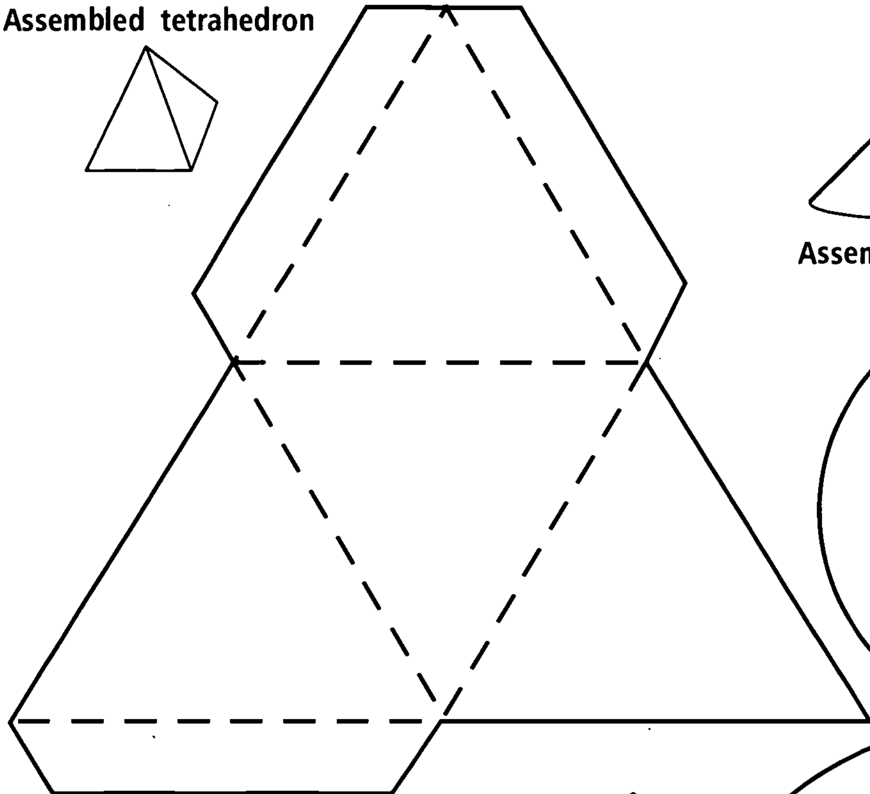
Using the data from chart above, create a graph and plot frontal surface area versus distance in drag units.

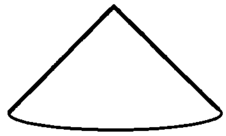
DISTANCE/FRONTAL SURFACE AREA



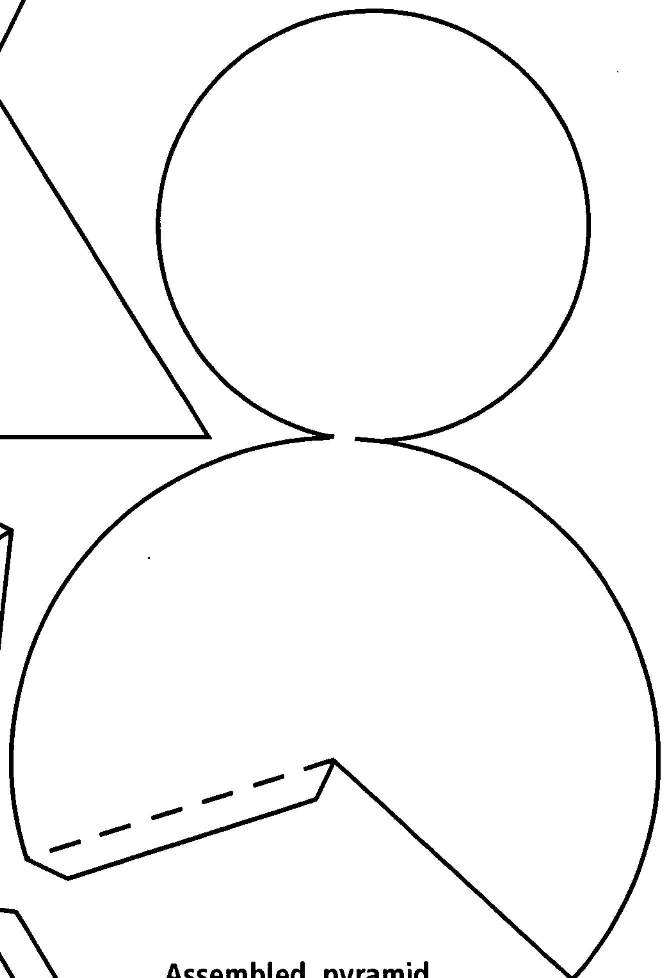
SHAPE PATTERNS

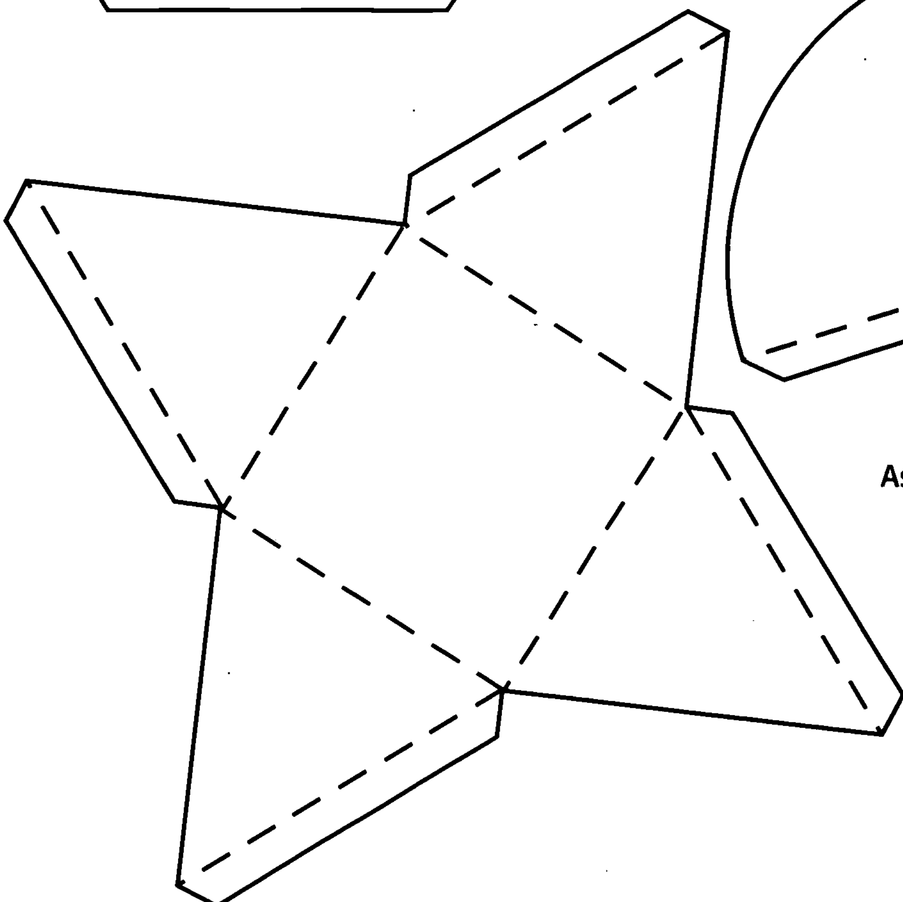
Assembled tetrahedron



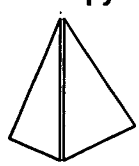


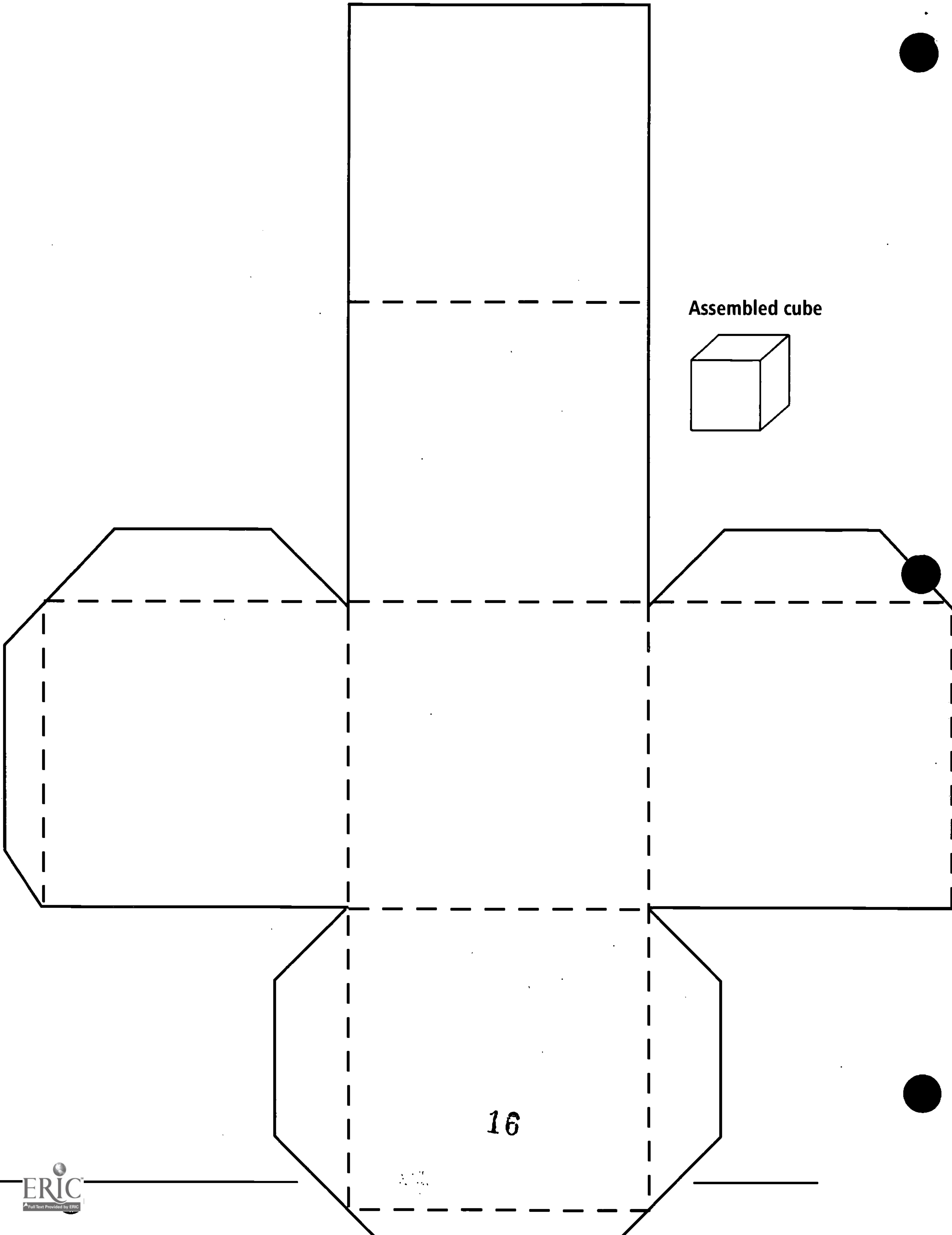
Assembled cone





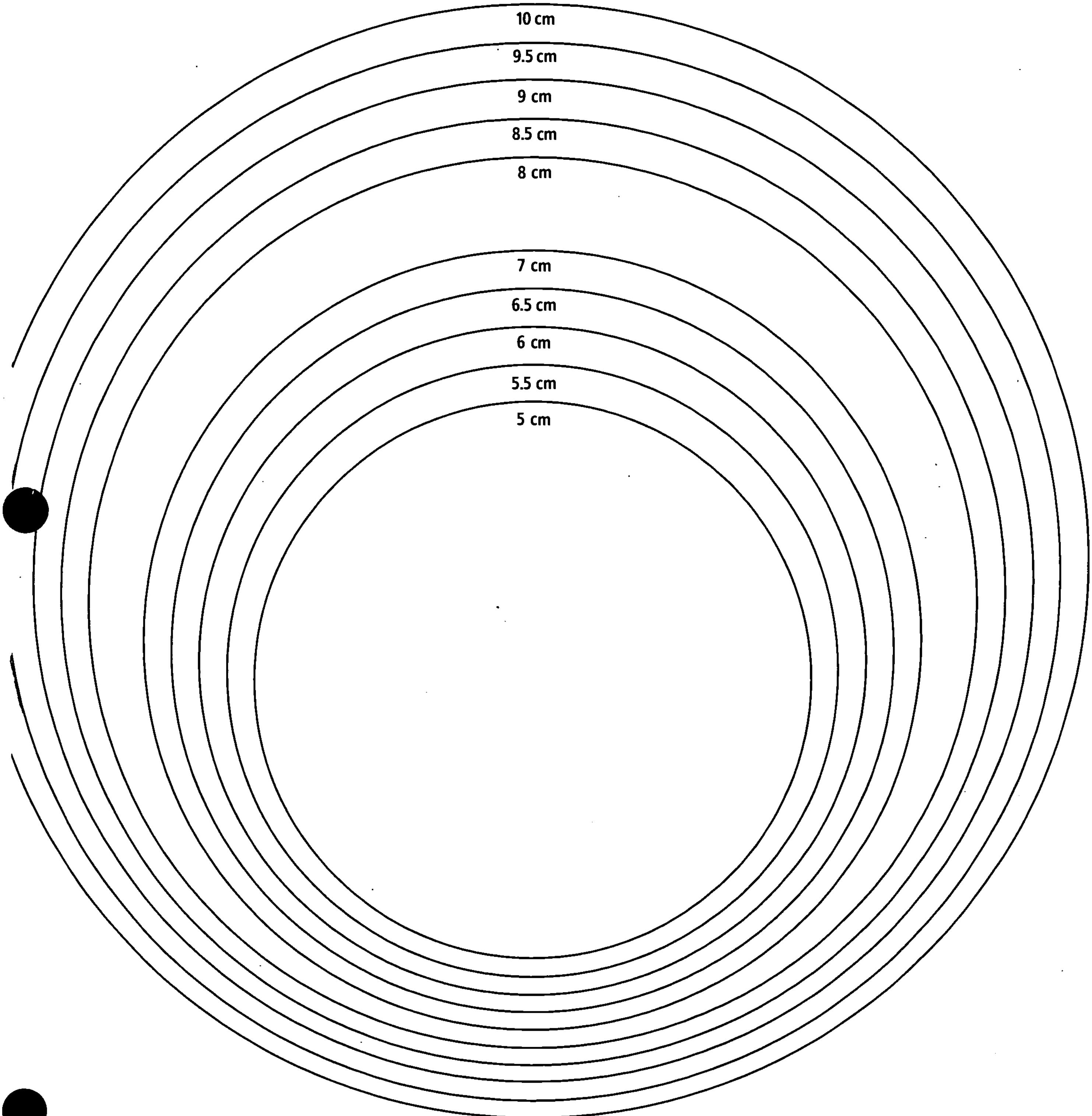
Assembled pyramid





Assembled cube

DISK PATTERNS



STUDENT CUE CARDS

Luther Jenkins, Aerospace Engineer, NASA Langley Research Center

1. Why are patterns important in determining drag? ______________________________

2. What algebraic relationship shows that a car has drag? ______________________________

3. Explain the relationship between pressure and "glow." ______________________________

Wendy Pennington, BWB-LSV Project Manager, NASA Langley Research Center

1. Describe the differences between the blended wing body and today's commercial airplanes. ______________________________

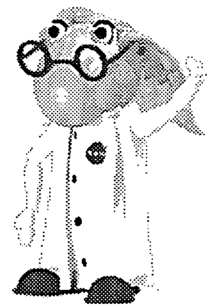
2. How do NASA engineers use geometry to estimate frontal surface area? ______________________________

3. What design features would increase drag on the low-speed vehicle and how would an engineer compensate for that drag? _

THE WEB ACTIVITY

THE ACTIVITY

MAX, or Mars Airborne eXplorer, is an interactive on-line activity developed by SPACE.com. It is supported by an integrated lesson plan with downloadable hands-on activities and teacher materials. These elements work together to introduce and reinforce the basic aerodynamic concepts needed for successful flight. MAX invites students to manipulate lift, drag, thrust, and weight to build and fly an airplane that will successfully drop life-seeking probes on Mars' surface. In addition, a lesson plan **(http://www.space.com/teachspace/airplane)** introduces the forces of lift, drag, thrust, and weight. Students can experiment with each force by using downloadable folded paper airplanes and other shapes.



To access MAX, visit Norbert's lab, **http://connect.larc.nasa.gov/flow/lab.html**

To access MAX, visit Norbert's lab, **http://connect.larc.nasa.gov/flow/lab.html** Norbert's lab contains links to additional on-line resources and a link to Career Corner, featuring researchers and NASA CONNECT team members. New this season is the NASA CONNECT Lab Manager. The Lab Manager offers assistance to teachers who would like to get the most from the site.

NATIONAL STANDARDS

TECHNOLOGY STANDARDS

- Develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.
- Use technology tools to enhance learning, increase productivity, and promote creativity.

SCIENCE STANDARDS

- Motions and forces
- Transfer of energy
- Abilities of technological design

MATHEMATICS STANDARDS

- Use mathematical models to represent and understand quantitative relationships.
- Analyze change in various contexts.
- Understand measurable attributes of objects and the units, systems, and processes of measurement.
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
- Understand and apply basic concepts of probability.
- Develop and evaluate inferences and predictions that are based on data.
- Apply and adapt a variety of appropriate strategies to solve problems.

INSTRUCTIONAL OBJECTIVES

Students will
- use critical thinking skills and problem solving skills to gain an understanding of lift, drag, thrust, and weight and how they affect an object's flight.
- test paper airplanes, changing one variable at a time to observe changes in lift, drag, weight, and thrust and compare their findings to a control plane.
- use technology to further their problem-solving skills and understanding of aerodynamic principles.

RESOURCES

BOOKS, PAMPLETS, AND PERIODICALS

Aeronautics. Mission Mathematics: Grades 5 - 8. Edited by Vincent O'Connor and Michael C. Hynes. Contributors Conni Blomberg et al. National Council of Teachers of Mathematics, Inc. 1997.

Bloomfield, Louis A.: *How Things Work: The Physics of Everyday Life*. John Wiley & Sons, Inc., NY, 1997.

Pappas, Theoni.: *The Magic of Mathematics: Discovering the Spell of Mathematics*. Wide World Publishing/Tetra, CA, 1999.

Science Explorer: Motion, Forces and Energy. Prentice Hall, NJ, 2000.

VanCleave, Janice.: *Physics for Every Kid. Flight, VI*. John Wiley & Sons, Inc. 1991.

WEB SITES

NASA Glenn Research Center's Teacher Resource Center
http://www.grc.nasa.gov/WWW/K-12/TRC/TRCactivities.html

Introduction to Aeronautics and how an airplane flies
http://quest.arc.nasa.gov/aero/background/

NASA Facts on-line; The Blended Wing Body
http://oea.larc.nasa.gov/PAIS/BWB.html

NASA Blended Wing Body Low-Speed Vehicle Design Challenge
http://edu.larc.nasa.gov/bwb

Technology Opportunity: Pressure Sensitive Paints
http://technology.larc.nasa.gov/PDF/TOPS/GRC/TOP3-00007.pdf

How Airplanes Fly **http://www.allstar.fiu.edu/aero/airflylvl3.htm**

Aeronautics Education Software
http://www.lerc.nasa.gov/WWW/K-12/aerosim/

Space facts, activities, news, live shuttle launches, and homework help.
http://www.spacekids.com

NASA Kids; Aeronautics, airplane design, four forces of flight
http://kids.msfc.nasa.gov/rockets/airplanes

The K-8 Aeronautics Internet Textbook **http://wings.ucdavis.edu**

NOTICE

Reproduction Basis

- [ ] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

- [x] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").