The FUTURES Channel®

MOVIE GUIDE

MOVIE NUMBER 1003

Flights of Imagination

The Movie:

Aeronautical inventor Paul MacCready describes how he built a human-powered airplane. Featured: Paul MacCready, Aeronvironment, Inc. *(Movie length: 3:08)*

Background:

Raising an airplane off the ground in defiance of gravity and common sense requires extensive knowledge of materials, the properties of air and the science of motion. For a while, it also required an engine, but advances in materials and engineering genius have now given us the reality of human-powered flight. But whether the craft you are flying in weighs 100 pounds, or 100 tons, it is reassuring to know that the same laws of physics which once kept us on the ground can, just as reliably, keep us in the air.

Curriculum Connections:

Fractions 1

Airplanes which are designed to fly with human power must be extremely light. In fact, more than half of the total weight of the vehicle in flight is due to the person who is flying it! If a certain human-powered airplane weighs 100 pounds empty, and 3/5 of the weight of the vehicle in flight is due to the person who is powering the plane, what would be the weight of that person?

Fractions 2

The metal from which airplanes are made needs to be both light and strong. Such materials are made by combining pure elements such as iron, copper, and so on. Metals made in this way are called *alloys.*

The alloy used in many airplanes is made mostly of aluminum. Here are some of the other materials that are in this alloy:

Element	Fraction of total weight
Manganese	$\frac{1}{40}$
Copper	$\frac{1}{60}$
Zinc	$\frac{2}{35}$

If you want to make 10,000 pounds of this alloy, how many pounds of Manganese would you need? Copper? Zinc?

What is the total fraction of manganese plus copper together?

If you have 5000 pounds of zinc, and all the other materials you need, how many pounds of alloy could you make?

Decimals

3

The parts of an airplane, and especially a human-powered airplane, must be very close to the sizes that are stated in the design. A part can be only a little bigger, or a little smaller, than the size it is supposed to be.

For example, a strut might be required to have a length of 28.275 inches, *plus or minus* 0.005 inches. This means that the diameter must be no smaller than 28.270 inches (28.275 + .005) and no larger than 28.280 inches (28.275 + 0.005).

Find the missing information for these parts:

Part	Size	Plus or minus	Largest allowed size	Smallest allowed size
Pedal Axle	Length = 4.750 in.	0.015 in.	?	?
Gear	Diameter = 0.875 in.	0.003 in.	?	?
Rudder cable	Diameter = 0.150 in.	?	0.152 in.	0.148 in.

Measurement (speed)

4

On December 17, 1903, Orville Wright made the first manned, heavier-than-air, powered flight in human history, traveling 120 feet in 12 seconds. The two Wright brothers made four flights that day, and in the last one Wilbur flew 852 feet in 59 seconds. What were the speeds of these two flights, in feet per second and miles per hour?

Geometry (angles)

5

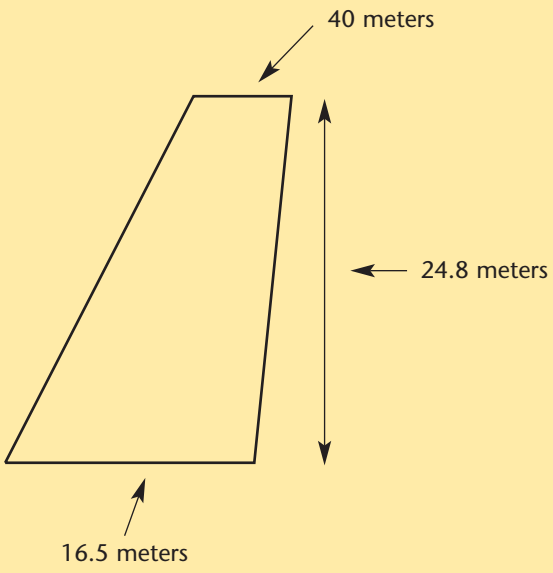
An important characteristic of airplanes is the angle at which the front edge of the wing meets the fuselage.

Use the World Wide Web to find pictures of several different types of airplanes, along with their speed range. Measure the wing-to-fuselage angle on each one. What conclusions can you draw?

Geometry (area)

6

The amount of lifting force that is provided by the wings of an airplane depends on their area. What is the area of this Boeing 747 wing?



Geometry (solid figures)

7

The A300 "Airbus" has a fuselage diameter of 18 feet 6 inches, and an overall length of 177 ft. Assume the shape is cylindrical to find its approximate volume.

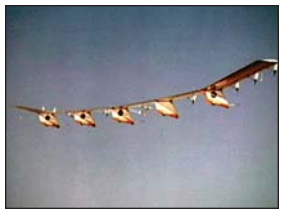
Ratios

8

The speed of sound is a very important number for airplane designers and jet pilots, because when an airplane travels close to that speed, the air that it is traveling through doesn't have enough time to "get out of the way", and so its resistance to the plane's motion is much greater. The speed of sound depends on the temperature of the air, humidity and other factors, but it is around 740 miles per hour.

"Mach number" is the ratio of the speed of an airplane to the speed of sound. It is named after Austrian physicist Ernst Mach. Use that definition to find the missing values in this table:

Speed of sound	Airplane speed	Mach number
740 mph	300 mph	?
740 mph	760 mph	?
750 mph	?	1.4
?	1100 mph	1.5



Ratios, Statistics

9

Design and carry out an experiment to see if the ratio of wingspan to total length for a paper airplane is related to how far it will fly.

Probability, Decimals

10

Commercial airplanes must be designed so that there is an extremely small possibility of equipment failure that could lead to an accident. One way to do this is to have backup systems, or more than one way to do things.

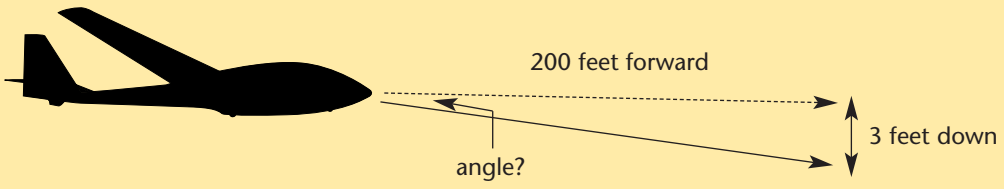
Suppose that there are two backup systems to the main system for turning the airplane, and all systems operate independently of each other. The probability of the main system failing in an hour of flight is 0.0002. The probability of the first backup system failing in an hour is .0001.

If you want the probability that all three will fail at the same time to be no more than 0.00000000001, what failure probability would be required for the third system?

Trigonometry

11

The glide ratio of an airplane states how far forward it will travel compared to how far it will fall when it is not being powered. For human-powered craft, it can be as high as 60:1. If an airplane moves forward 200 feet while falling 3 feet, at what angle is it descending?

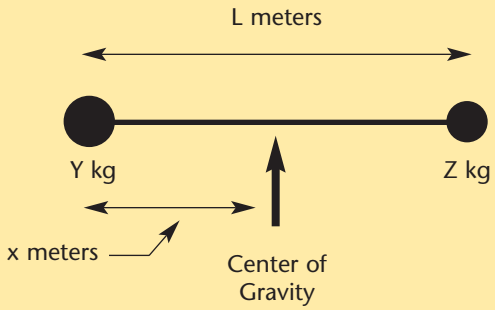


If an airplane glides at a descent angle of 2 degrees, what is its glide ratio?

Algebra (expressions and equations)

It is important that the weight in an airplane is placed so as to keep the airplane balanced. If all of the weight were in the back, for example, when the plane was in flight the weight would tend to pull the tail down.

This diagram shows two weights connected by a rod. The "Center of Gravity" of this structure is the place where you could lift it without it tilting one direction or another.



As *Y* increases (the weight on the left becomes heavier), what do you think will happen to *x* (the distance from that weight to the center of gravity)?

As *Z* increases, what will happen to *x*?

Use this formula to find the missing values in the table:

$$\frac{x}{L - x} = \frac{Z}{Y}$$

Y (kg)	Z (kg)	L (meters)	Y (meters)
100	100	?	5
100	?	30	20
100	50	15	?
10	90	100	?

If you enjoyed this Futures Channel Movie, you will probably also like these:

Inventing with Polygons, #1007	This inventor uses polygons to build amazing expandable structures.
The Pterodactyl Flies Again, #1002	A young aeronautical designer creates a flying replica of a prehistoric dinosaur.
Maglev Trains, #1004	Gliding on a wave of electromagnetic force, a maglev (magnetic levitation) train could travel at 300 miles per hour or faster. Designer-engineers Gordon Danby and James Powell describe the mechanics and future benefits of such superconductor trains.