Main Course

BREEZES BLOWING; VIDEO

Along with the movement of air masses comes wind. The winds are horizontal for the most part—high-pressure air moving toward low-pressure air. SKIP

GLIDER RIDE; VIDEO

Vertical winds, or up and down winds, are associated with convection currents where again, low-pressure air is rising and high-pressure air is moving in to occupy the space. Vertical winds allow a particular sport enjoyed by thousands of people nationwide. Based on what you see here, can you guess what that might be? *[Accept all reasonable responses; students probably will suggest flying.]* Airplanes are able to fly for a number of complicated reasons, most related to Newton's Laws of Motion and the concept of lift. Lift requires power, and that's why airplanes and jets have engines. But, there actually are planes that have no engines at all, and yet can fly safely for minutes or hours before landing gently at a place of the pilot's choosing. Do you know what those planes are called? *[Gliders or sail planes]* Gliders get their power from the force of gravity and, get this, rising columns of warm air, called thermals. To take advantage of these thermals, a pilot needs to get his or her glider into the air. For that, a tow by a powered plane is required. Watch. (58 seconds duration) SKIP

LAST FRAME OF GLIDER RIDE

Looks easy, doesn't it? Here's a question: since air is invisible, how do you think a glider pilot might find a thermal? *[Accept all reasonable speculation.]* One thing a pilot might do is to look for circling birds. They've already found a thermal. Another thing a pilot might consider is the terrain he or she is flying over. Plowed fields and large parking lots are dark in color. They're likely sources of rising thermals. Still another trick glider pilots have up their sleeves is to look for cumulus clouds. Can you explain why? *[Accept all reasonable explanations. The top of a column of rising warm air will eventually reach an altitude where the air temperature is sufficiently cool to cause an increase in the rate of condensation and yield a cloud.]* Glider pilots are very passionate about flying. They even hope that someday you'll join them in this exhilarating sport. *[See Page 82 for more information related to gliders.]*

Now, back to winds. We've seen and experienced gentle breezes blowing, and we know for sure now that vertical winds are common in the troposphere. SKIP

STRONG WIND BLOWING; VIDEO

And one characteristic of wind is true whether it's blowing horizontally or vertically: the greater the difference in pressure between the high- and low-pressure air masses, the harder the wind blows. (5 seconds duration) SKIP ⏭

LAST FRAME OF STRONG WIND BLOWING

Let's get back to air masses. Given what you now know about air pressure and air masses, what kind of weather might you expect if a high-pressure air mass were overhead? SKIP ⏭

U.S. MAP; H AIR MASS MEETING L AIR MASS; ANIMATION

Typically, high-pressure air is cool and dry, and fair weather prevails. Conversely, low-pressure air masses are often warm and wet. Remember, warm air expands, and at the same time, more and more water molecules enter the atmosphere as water vapor. As air masses move, they take their weather with them, so to speak. (10 seconds duration) SKIP ⏭

LAST FRAME OF H AIR MASS MEETING L AIR MASS

When two air masses meet, well… all manner of things can happen weather-wise. SKIP ⏭

FRONTAL BOUNDARY; H AIR MASS MEETING L AIR MASS; DIAGRAM

For example, if it's raining where you are, eventually a high-pressure air mass will move in, bringing cooler, drier air. That's a high-pressure air mass at left, and a low-pressure air mass at right. Look what's happening at the boundary where they meet. SKIP ⏭

FRONTAL BOUNDARY; L AIR MASS MEETING H AIR MASS; DIAGRAM

When a high-pressure air mass begins to weaken, air pressure drops and clouds form, and rain or snow may not be far behind. Here we see two examples of what can happen when a low-pressure air mass moves in. At top, the incoming air mass is stable. Notice the progression of clouds—cirrus to nimbostratus. At bottom, the incoming air mass is unstable. In such cases, cumulonimbus clouds can form at the boundary. SKIP ⏭

H AIR MASS MEETING L AIR MASS; COLD FRONT LABELED; DIAGRAM

Fronts are boundaries between air masses. And a front is always named for the incoming air mass. In other words, if a cold, dry air mass is moving in, then that boundary is called a cold front. What is a warm front? (a boundary where warm air is entering an area) Precipitation is likely to occur at frontal boundaries. SKIP ⏭

SATELLITE IMAGES OF WEATHER; TIME-LAPSE VIDEO

Before we look at some of the more dramatic interactions between air masses, let's briefly consider what makes air masses move how they do and where they do. Sure, convection plays a big role in the movement of air masses. The winds drive them across Earth's surface. But do the air masses follow straight paths? Actually, no. The air moving from a high-pressure area to a low-pressure area takes a spiral path. Why? Because another force acts on air masses that makes their movement somewhat more predictable. (20 seconds duration) SKIP ⏭

LAST FRAME OF TIME-LAPSE VIDEO OF SATELLITE IMAGES OF WEATHER

And to study that mysterious force, all you have to do is observe our planet as it spins in space. SKIP ⏭

MODEL OF HOW AIR MIGHT FLOW ACROSS A STATIONARY SPHERE; ANIMATION

If Earth didn't rotate, you might predict that rising warm air masses at the equator would move away from the equator and straight to the poles, and that sinking polar air masses would move straight to the equator, creating giant convection cells between the equator and the poles. (10 seconds duration) SKIP ⏭

LAST FRAME OF ANIMATION OF HOW AIR MIGHT FLOW ACROSS A STATIONARY SPHERE

But instead of one giant cell of air moving between, say, the equator and the North Pole… SKIP ⏭

NORTHERN HEMISPHERE; THREE CYCLES OF AIR; ANIMATION

…there actually are three smaller cells. And three similar cells can be found between the equator and the South Pole. (15 seconds duration) SKIP ⏭

LAST FRAME OF ANIMATION OF THREE CYCLES OF AIR

This observed pattern of air movement between the equator and the poles is the effect of uneven heating of Earth's surface that results in high- and low-pressure air masses combined with… the spinning Earth. SKIP ⏭

SPINNING EARTH; APPARENT AIR DEFLECTION; ANIMATION

Yep, that's right, the spinning Earth. Because Earth turns on its axis, air masses don't travel in straight lines across its surface. Watch. SKIP ⏭

APPARENT AIR DEFLECTION ANIMATION **NARRATION** (30 SECONDS DURATION)

> *"As Earth spins below the moving air masses, they appear to turn toward the right in our hemisphere, and toward the left in the Southern Hemisphere. This apparent deflection of the wind by the rotation of Earth is known as the Coriolis effect or the Coriolis force."*

LAST FRAME OF APPARENT AIR DEFLECTION ANIMATION

Here's the deal with the Coriolis force. First, the name. SKIP ⏭

PATHS OF AIR DEFLECTION; CORIOLIS FORCE LABELED

Back in 1835, a French engineer/mathematician named Gaspard-Gustave de Coriolis was the first to describe the force mathematically. And so, it was named in his honor. Does that take away a little of the mystery? SKIP ⏭

GLOBE SPINNING; VIDEO

Next, consider the Earth—actually this model of the Earth, a globe. Watch. SKIP ⏭

GLOBE SPINNING **NARRATION** (45 SECONDS DURATION)

> *"Earth spins west to east once around on its axis each day. Whether you live at the equator or at the North Pole, you still only go around once in 24 hours. But consider the shape of the Earth for a minute. Notice how the distance around is much greater at the equator than at the poles. And so, when Earth makes one orbit, an object at the equator actually travels much farther than an object at the pole. Are you with me so far?*
>
> *"Now, think about this. Since both objects make a full rotation in the same amount of time, you have to figure that the object at the equator has to move much faster than the object at the pole. True?*
>
> *"Now, if an object, let's say an air mass, began moving from the equator northward toward the North Pole, it would keep its initial eastward speed as it moved. Pretty soon, it would be moving faster than the ground below it. It would appear that the air mass was veering to the right, or eastward."*

LAST FRAME OF GLOBE SPINNING VIDEO

Stick with me. We're almost there. SKIP ⏭

STATIONARY AND SPINNING GLOBE; CHALK SHOWS PATH OF AIR MASS; VIDEO

Let's try this again, from the North Pole, this time. SKIP ⏭

STATIONARY AND SPINNING GLOBE **NARRATION** (20 SECONDS DURATION)

> *"Let's say an air mass began moving southward from the pole toward the equator. It would keep its initial eastward speed as it moved down. Pretty soon, it would be moving slower than the ground below it. It would appear that the air mass was veering to the right, or westward."*

LAST FRAME OF GLOBE STATIONARY AND SPINNING GLOBE VIDEO

And so, this mysterious force, the Coriolis force, is simply the *appearance* that something, like an air mass, is being deflected to the right. SKIP ⏭

PATHS OF AIR DEFLECTION; CORIOLIS FORCE LABELED

In the Southern Hemisphere, by the way, the Coriolis force causes an apparent deflection of air masses to the left. All that is happening is that the ground is moving at a different speed than the starting ground speed of the air mass. And the air mass keeps its starting speed as it moves north or south. SKIP ⏭

SATELLITE IMAGES OF CLOUDS MOVING ACROSS UNITED STATES; TIME-LAPSE VIDEO

How do you know the Coriolis force is alive and well? If you study weather patterns in the United States, you'll notice that the general movement of air masses is from west to east across the country. Thank you, Coriolis force. (20 seconds duration) SKIP ⏭