Frosty

Objective:	To learn about the NASA Icing Research Tunnel and the impact of precipitation on aircraft.

Grade Level: 9-12
Subject(s): Physical Science, Chemistry, Technology
Prep Time: < 10 minutes
Duration: 50 minutes
Materials Category: Special

National Education Standards	
Science	3d, 7f
Mathematics	
Technology (ISTE)	
Technology (ITEA)	3a, 3d
Geography	

Materials:

- Two tin cans
- Ice
- Ice cream salt (rock salt)
- Two thermometers
- Student Sheets (one per student)

Related Links:

NASA's Icing Research Tunnel
http://facilities.grc.nasa.gov/irt/

Wind Tunnels
http://www.grc.nasa.gov/WWW/K-12/WindTunnel/windlist.html

Supporting NASAexplores Article(s):

Flying On The Ground
http://www.nasaexplores.com/show2_articlea.php?id=01-059

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Teacher Sheet(s)

Background Information

Where there is visible moisture in the air, there is going to be the probability of icing. Icing can occur any place on the aircraft, but it is more dangerous in several places: the wings, the propeller, the pitot tube, and the carburetor. Pitot tubes are used on aircraft as speedometers. On course, icing on antennas can also interfere with radios and even put them out of operation if they break off, and structural icing will produce more drag.

There are systems that can combat icing. The carburetor heat can be used to preclude carburetor icing, which can form at temperatures as high as 21 degrees Celsius (˚C) [70 degrees Fahrenheit (˚F)] outside temperature due to the cooling that takes place inside the carburetor. Larger aircraft are also more likely to have liquid de-icing system for the propeller that, if severely iced, can cause enough loss of thrust to cause a crash, and de-icing systems for the wings that lose lift rapidly as the shape of the wing is distorted by the ice formation.

These systems can be the liquid type or the rubber boot type, which expands and contracts to break off the ice. Jet engines and wings are also susceptible to icing and generally use hot-air heating of the intakes and wings to prevent ice from forming. Of course, any pilots experiencing icing will immediately change their altitude as the best way of combating it. The temperature changes -16 ˚C (3.5 ˚F) with every 304.8 meters (1,000 feet) in altitude.

Guidelines

1. Read orally the 9-12 NASAexplores article, "Flying On The Ground." Discuss the testing performed inside wind tunnels.
2. Have students explain the differences between evaporation and condensation. Evaporation is the changing of a liquid into a gas, whereas condensation is the changing of a gas into a liquid. When the air is cooled, water vapor might condense.
3. Hand out materials and Student Sheets.

Discussion / Wrap-up

- Review questions and answers with students.
- Ask students, "Besides testing aircraft in the Icing Research Tunnel, can you think of other uses for the tunnel?"

Extensions

- Use the Internet or a news channel to track weather patterns around the world.
- Research weather-related aircraft crashes, or research the history of wind tunnels.
- Build a wind tunnel, and test paper airplanes or other objects.

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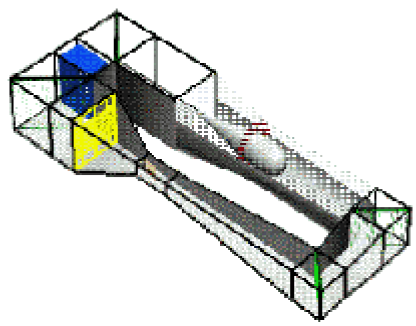
Student Sheet(s)

Background Information

During World War II, over 100 cargo planes en route from India to China were lost, most because of severe icing. Aircraft icing is not as critical today because these problems are solved on the ground in the NASA Glenn Icing Research Tunnel (IRT). The IRT team performs research activities related to the development of methods for evaluating and simulating the growth of ice on aircraft surfaces, the effects that ice may have on the behavior of aircraft in flight, and the behavior of ice protection/detection systems.

The NASA Glenn IRT is the oldest and largest refrigerated icing wind tunnel in the world. It has been used to research ice detection systems and to develop icing technologies used on many of today's aircraft. The IRT is able to duplicate nature's icing conditions that aircraft typically encounter. The conditions are simulated using a refrigeration plant and a spray bar system that generate an icing cloud in the tunnel.

The IRT is capable of producing airspeeds from 80.5 to 643.7 kilometers per hour (km/hr) [50 to 400 miles per hour (mph)] and temperatures as low as -20 degrees Celsius (˚C) [-20 degrees Fahrenheit (˚F). It has 10 spray bars with 100 nozzles that produce supercooled water droplets that can form a 1.2 meters (m) [4 feet (ft)] high by 1.8 m (6 ft) wide ice cloud.



In the IRT, researchers study:

- how ice forms on aircraft surfaces—given the geometry, the airspeed, the temperature, and cloud characteristics
- how the ice affects the wing/inlet performance
- how to remove ice or keep it from forming—ice protection systems

Inside, a 4,160-horsepower electric motor generates 483 km/hr (300 mph) air in a 1.8- x 2.7-m (6- x 9-ft) test section. The 2,100-ton refrigeration system can cool the air to -40 ˚C (-40 ˚F). However, cold air by itself cannot produce icing. There must be water vapor and droplets in the air to condense and freeze on the aircraft surfaces. A spray system simulates a natural icing cloud of tiny droplets. The aircraft in the test section is forced to fly through a cold, supersaturated cloud of air—resulting in rapid ice buildup on the craft. As the deadly layers grow, heating elements in the crucial aircraft components go into action, and the detached ice shards fly off downstream. Cameras record the whole sequence to show engineers where to make improvements in the de-icing system.

Materials

- Two tin cans
- Ice
- Ice cream salt (rock salt)
- Two thermometers
- Student Sheets

Procedure

1. Place ice cubes and a handful of rock salt in a metal can. Put the thermometer in the can.
2. Add only ice in the other can.
3. Stir the ice slowly with the thermometer in each can. Watch the outside of the cans. When water forms on the outside, record the temperature.

Questions

1. What caused the formation of water on the outside of the can?
2. What is the purpose of putting rock salt in one of the cans?
3. How can you compare this simple activity with the IRT?
4. Explain the processes of evaporation, condensation, and precipitation.
5. Why is icing research important for air travel?
6. How does the U.S. aircraft industry benefit from the research conducted by the NASA IRT?
7. What are the advantages and disadvantages of testing a small model of a full-size aircraft?
8. If ice began to form on an airplane, which two parts of the airplane are the most critical to keep ice free in order to maintain a safe cruising speed?
9. What is required before precipitation can occur?
10. When is there a good possibility of icing occurring?
11. At what outside temperature can icing occur?