1.0 hours

Coriolis Effect

Instructor Notes

Suggested Correlation of Topics

Air and its movements, atmospheres, circulation of air or sea, meteorology, ocean currents, physics: forces and mechanics, planetary rotation

Purpose

The objective of this exercise is to demonstrate that an object which moves in latitude over the surface of a rotating planet experiences the Coriolis effect, an apparent deflection of its path from a straight line. Upon completion of this exercise the student should understand the concept of the Coriolis effect and be able to understand viewing an event from different frames of reference.

Materials

Suggested: lazy susan type turntable (must be able to be rotated clockwise and counterclockwise), paper, tape, markers (3 colors)

Background

The Coriolis effect is caused by an "imaginary" force but has very real effects on the weather of Earth and other planets. On Earth, which spins counterclockwise as viewed from above its north pole, objects are deflected to the right in the northern hemisphere and to the left in the southern hemisphere. This deflection is only apparent, however, as an observer watching from space would see the object's path as a straight line. It is because we are viewing in the frame of reference of the rotating Earth that we see the apparent deflection.

This exercise demonstrates the Coriolis effect by using a rotating turntable. Students will draw straight lines while spinning the turntable in different directions. To their surprise the resultant lines will be curves on the paper covering the turntable. This apparent deflection, the Coriolis effect, only occurs in the frame of reference of the turntable. The students, in a different frame of reference, know that the path of the marker used to draw the line was straight. On the sphere of the Earth, we occupy the same reference frame as the motion, so we "see" the Coriolis effect in action. To an outside observer, who is occupying another reference frame, there is no deflection and the motion is a straight line.

This concept has important implications for the motion of ocean currents, storms on Earth, and even missiles, but is unimportant at smaller scales. In combination with pressure effects, the Coriolis deflection gives rise to a counterclockwise rotation of large storms, such as hurricanes, in the northern hemisphere, and clockwise rotation in the southern hemisphere. This could be illustrated to students through pictures of hurricanes or other large storms found in newspapers, magazines, or elsewhere in this lab manual.

Students should work in pairs, one spinning the turntable at a constant speed and the other marking the line. Instructors should note that the spinning of the Earth once a day on its axis is called rotation. Students can experiment with rotating their turntable faster or slower to see the effect on the drawn lines. A faster spin will result in greater deflection. If time or materials are a problem, this exercise can be done as a demonstration by the instructor.

Vector motion of the surface of a sphere is complex. The magnitude of the Coriolis effect is controlled by rotation about the vertical axis. On Earth the vertical axis of rotation is a line connecting the geographic north and south poles. On a rotating sphere, the maximum rotation is at the poles; there is no rotation about the vertical axis at the equator. To visualize this, imagine two flat disks glued onto the surface of a sphere, one at the north pole and one at the equator. As the sphere rotates, the disk at the north pole rotates around the vertical rotation axis of the sphere. The vertical axis of the sphere is also the axis of rotation of the disk. If viewed from above, the disk spins in one spot, just as the sphere does. The surface of the disk at the equator is parallel to the vertical rotation axis of the sphere. When the sphere rotates, this disk revolves around the axis. There is no spin or rotation of the disk at the equator. The magnitude of the Coriolis effect increases from the equator where it has no effect to the poles. The turntable is equivalent to the disk at the pole of the sphere, and illustrates the maximum Coriolis effect.

The Coriolis effect operates on Mars in a similar way as on Earth. Because Mars rotates at about the same rate and in the same sense as Earth, Mars has large-scale weather systems just like on the Earth. Students might try to predict the direction that the Coriolis effect would deflect objects on Venus or Uranus, which spin clockwise as viewed from "above" (north of) the solar system. Advanced students and upper grades can answer the optional starred (*) question, which applies their observations to more complex situations.

Science Standards

- Earth and Space Science
    - Origin and evolution of the Earth system

Answer Key

1. The line is straight.
2. Unlike the real Earth, this model is not rotating.
3. The line was deflected to the right.
4. Counterclockwise.
5. It would be deflected to the right.
6. It was deflected to the left.
7. Clockwise.
8. It would be deflected to the left. [The direction of travel does not matter in the deflection, all directions of travel are deflected to the right in the northern hemisphere and to the left in the southern hemisphere.]
9. Objects in the northern hemisphere are deflected to the right, while those in the southern hemisphere deflect to the left.
10. The streaks form a curved path.
11. The streaks are curved because there is a Coriolis effect on Mars.
12. Yes; for there to be a Coriolis effect on Mars, the planet must rotate.
13. The wind blew from the north.
14. The wind is being deflected to the left.
15. Deflection to the left indicates we are looking at the southern hemisphere of Mars.

*16. The Coriolis "force" is an imaginary force because objects affected by it are really following a straight path. It is an apparent deflection we see from the vantage point (frame of reference) of the rotating Earth.

Name ______________________________

Coriolis Effect

Purpose

By tracing an object as it moves across the surface of a rotating and a non-rotating model, you will demonstrate the true and apparent motions of objects as they move across the real Earth. This apparent motion is known as the **Coriolis effect**.

Materials

For each student group: Turntable which can be spun both ways, paper, tape, colored markers (3)

Introduction

The Coriolis effect is the name given to the imaginary force that deflects objects, such as rockets or large storms, which move over the surface of some planets. It is important in causing the swirling motion of storms, including hurricanes. The Coriolis effect occurs on Earth and other planets because the planets rotate.

Questions

Cover the turntable with the paper, taping it to the edges of the turntable. Use one of the markers to draw a straight line all the way across the turntable. This shows the path of clouds or objects moving on a non-rotating planet.

1. Observe and describe the shape of the line you drew. Looking down on your line, is it straight or curved?

2. What is wrong with (missing from) this model of the Earth that might affect how objects truly move over the Earth's surface?

Now spin the turntable counterclockwise. This is the direction that the Earth turns (or rotates), when viewed from the north pole. The turntable is modeling the northern hemisphere of the Earth. Draw a straight line across the turntable using a different colored marker, while spinning it at a constant speed. Be sure to watch that your marker follows a straight path! Label the beginning of the line you drew with an arrow pointing in the direction the marker moved. Note that the line you drew is a curve.

3. With the starting point of the line directly in front of you, in which direction was line deflected? (Which way does the arrow point—right or left?)

4. Which direction does the line curve (clockwise or counterclockwise)?

5. If you were in an airplane that takes off from Miami, Florida and is flying to Toronto, Canada, would your plane be deflected to the left or to the right as it flew?

Now spin the turntable clockwise. This is the direction that the Earth turns (or rotates), when viewed from the south pole. The turntable is modeling the southern hemisphere of the Earth. Draw a straight line across the turntable using a different colored marker, while spinning it at a constant speed. Be sure to watch that your marker follows a straight path! Label the beginning of the line you drew with an arrow pointing in the direction the marker moved. Note that the line you drew is again a curve.

6. With the starting point of the line directly in front of you, in which direction was line deflected? (Which way does the arrow point—right or left?)

7. Which direction does the line curve (clockwise or counterclockwise)?

8. If you were in a cruise ship that set sail from Cape Town, South Africa and was sailing for Rio de Janeiro, Brazil, would your ship be deflected to the left or to the right as it traveled?

9. What is the difference between the way objects move over the Earth in the northern hemisphere compared with those in the southern hemisphere?

Examine Figure 7.1, which shows part of Mars. The bright streaks associated with some craters can be used as wind direction indicators. They are deposits of dust that can form downwind from craters.

10. Does the group of streaks form a straight or a curved path (as a whole group)?

11. What does the shape of the wind streaks indicate about the existence of a Coriolis effect on Mars?

12. Does Mars rotate? How do you know?

13. From which way did the wind blow to make the streaks in Figure 7.1?

14. Imagine you are on the part of Mars shown in this figure, standing with the wind to your back. Which way is the wind being deflected, to your left or your right?

15. If Mars rotates in the same direction as the Earth (from west to east), is this a picture of the northern or southern hemisphere of Mars?

Optional Question

*16. Why is the Coriolis “force,” which causes objects to deflect from a straight path on a rotating planet, sometimes called an imaginary force?

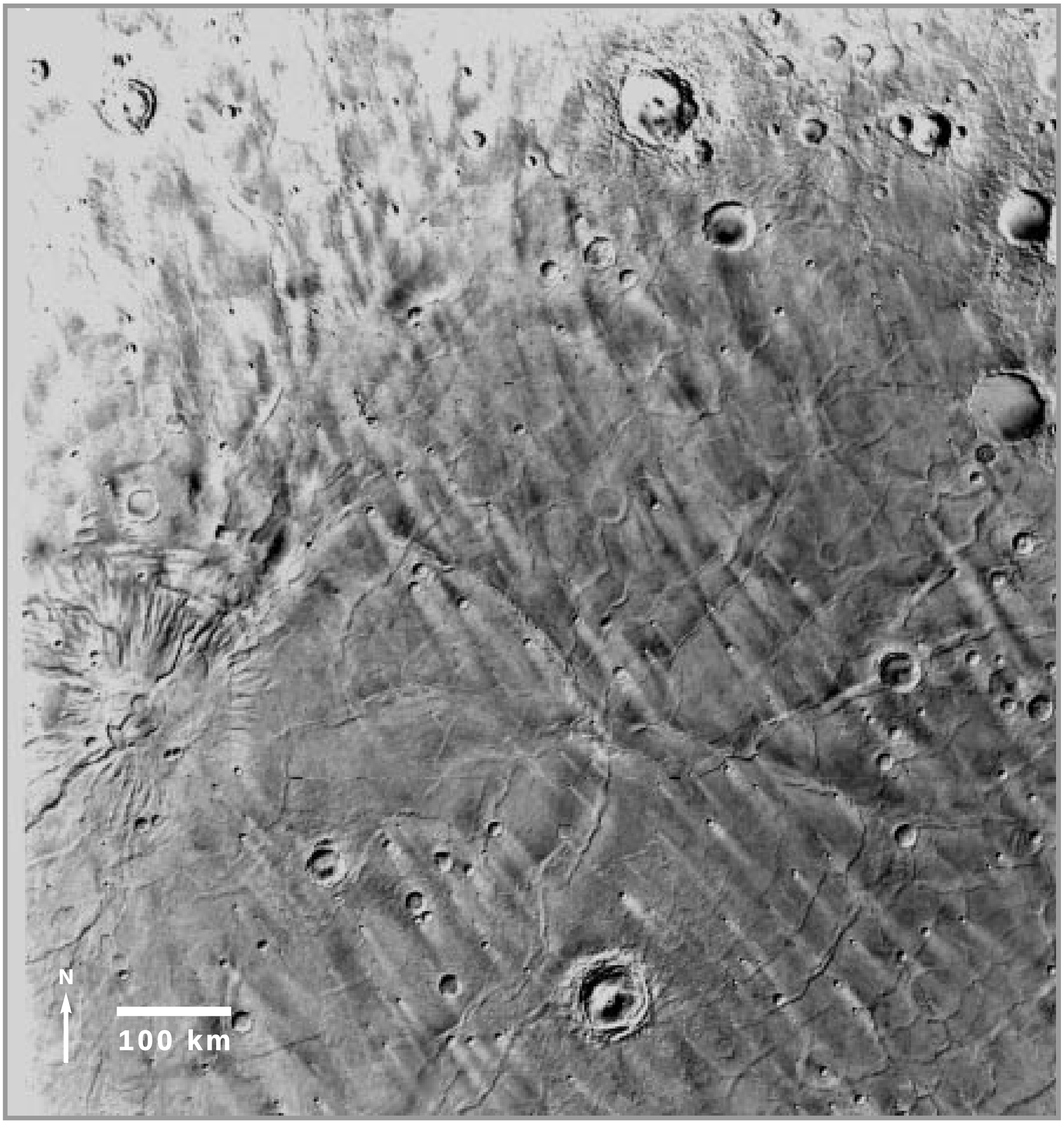

Figure 7.1. *Centered at 20˚, 250˚W, this mosaic is of a region on Mars called Hesperia Planum, site of much aeolian (wind) activity. Note the bright streaks associated with some of the craters; they can be used as wind direction indicators. North is to the top. Viking Orbiter mosaic 211-5478.*