The Coriolis effect - summary sheet

AS3 - Spring 2002 - Fovell

Key points regarding the Coriolis force (applicable to Northern Hemisphere [NH]):

1. It affects any object (air parcel, missile, train) moving over an appreciable distance ($\geq$ 100-200 mi or so) on the Earth
   - thus, it does not affect the sea-breeze, tornadoes, pitched baseballs and water flowing down the kitchen sink
2. It attempts to force object to curve to the right following its motion in the NH. (However, whether objects do curve rightward depends on whether other forces are acting.)
3. It is proportional to object speed - and does not affect stationary objects
4. It exists due to the Earth's rotation, and **NOT** because the Earth turns beneath moving objects
   - every object on Earth spins because the Earth does
   - an object's spin rate depends on its distance from spin axis (i.e., it's *latitude*; see Figure 1 - left)
     - equatorial objects spin fastest since they're farthest from spin axis
   - this spin gives the object *angular momentum*, which is conserved as it moves on the Earth
     - momentum = mass x velocity
     - angular momentum = momentum in a circular path of a given *radius*
     - thus angular momentum = mass x spin velocity x radius
   - if you decrease (increase) an object's radius of spin, its rate of spin increases (decreases) [think of: figure skater]
     - to decrease an object's spin radius, move it to the **north**, closer to spin axis - its spin rate must increase.
     - to increase an object's spin radius, move it to the **south**, farther from the spin axis - its spin rate must decrease
     - this is necessary so the object's angular momentum stays same

Detailed example of the Coriolis rightward deflection (see Figure 1 - right). It is presumed only Coriolis is acting on the object. Key point: the object starts with the Earth spin velocity of its original latitude and when displaced tries to return to its original latitude. Numbers below correspond to reference points in figure. Earth spins from west to east.

1. Start with object located at latitude of Chicago (40 North). Move object to the south, it moves away from the spin axis. This increases its radius and decreases its spin velocity. However, at the same time, the spin velocity of ground beneath is increasing as it moves southward, towards equator. Object cannot keep up with the increasing spin rate below.

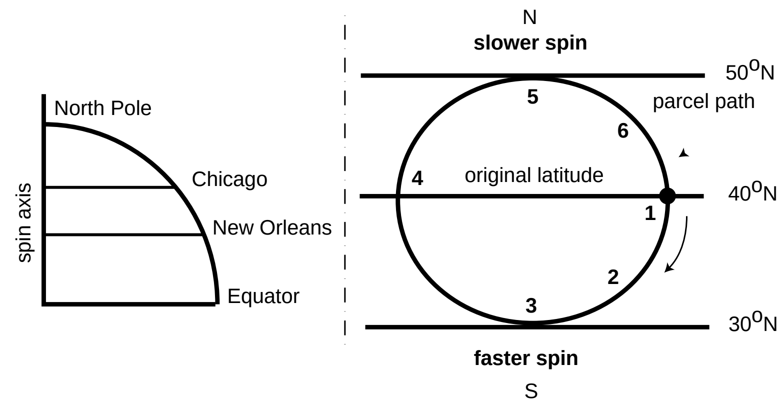

Figure 1: *Left:* Distance to spin axis increases towards equator. *Right:* Inertial (Coriolis) circle for a displaced object originating at 40N latitude

2. Therefore, object curves *westward*, against the Earth's spin direction, thereby reducing its spin relative to the Earth below the object. Curving tendency is to object's *right*.

3. Object continues to curve right as it tries to return to its original latitude (40 N). Soon, it starts heading northward (but still curving to its right).

4. It overshoots original latitude because it still has an acceleration. This carries the object north of its original latitude, where the Earth has less spin velocity than the object. Meanwhile, object's distance from spin axis decreases, thus increasing its spin velocity.

5. Object, now with excess spin, bends *eastward* towards the Earth's spin direction, increasing the object's spin velocity relative to the solid Earth below. Note, however, that the object is **still** curving to its right.

6. Object continues curving rightward and eventually starts moving towards the south and again reaches its original latitude. The object may continue in an endless loop, called an *inertial or Coriolis circle*. This explains the principal ocean currents.

7. Minor, unimportant point: The circle isn't actually a perfect circle (as shown) because of the sphericity of the Earth. If the Earth were flat, it would be a perfect circle.

Final note: candidly, there is something missing from this story. The rightward curvature owing to the northward and southward displacements has been adequately explained using angular momentum conservation, but we actually need a better explanation for why eastbound objects curve south and the northward deflection of westbound objects. Though this is beyond the scope of this course, any ideas what it is?