Air Pressure and Winds

Chapter Six gives us a broad view of how and why the wind blows. It opens with a section on atmospheric pressure. This is followed by a section that describes surface and upper-air charts. The next section examines the forces that influence atmospheric motions. Here we learn that the wind blows in response to differences in atmospheric pressure and that once air begins to move, the Coriolis force tends to bend it to the right of its intended path in the Northern Hemisphere and to the left in the Southern Hemisphere. The chapter then looks at how the winds blow around pressure systems in the Northern and Southern Hemispheres, both aloft and at the surface. The latter part of the chapter deals with measuring and determining wind direction and wind speed.

Some important concepts and facts of this chapter:

1. Air pressure can be described as a measure of the total mass of air above any level or as the force exerted by air molecules over a given area.

2. Atmospheric pressure decreases most rapidly with elevation in a cold column of air.

3. Cold air aloft is normally associated with low atmospheric pressure, while warm air aloft is associated with high atmospheric pressure.

4. The barometer is the instrument that measures air pressure.

5. The amount of pressure change that occurs over a given horizontal distance is the pressure gradient.

6. Horizontal differences in pressure create a pressure gradient force (PGF). This force causes the wind to blow.

7. On a weather map, closely spaced isobars (or contours) represent a steep pressure gradient, a strong PGF, and high winds, while widely spaced isobars (or contours) represent a gentle pressure gradient, a weak PGF, and light winds.
8. The Coriolis force causes the wind to bend to the right of its path in the Northern Hemisphere and to the left of its path in the Southern Hemisphere.

9. Above middle and high latitudes, the winds on an upper-level chart tend to blow parallel to contour lines (or isobars) in a roughly west-to-east direction in both hemispheres.

10. In the Northern Hemisphere, winds on a surface weather map blow clockwise and outward from the center of a high; counterclockwise and inward toward the center of a low.

11. Sinking air occurs above a surface high-pressure area; rising air above a surface low-pressure area.

12. The prevailing wind is the direction from which the wind blows most frequently during a given time period.
SELF TESTS

Match the Following

1. The amount of pressure change that occurs over a given horizontal distance
2. An apparent force created by the rotation of the earth
3. Wind aloft that blows in a straight line at a constant speed parallel to the isobars or contours
4. To correctly monitor horizontal changes in air pressure, this is the most important correction added to the station pressure
5. Indicates the percent of time the wind blows from different directions
6. Instrument that employs Doppler radar to obtain a vertical profile of wind speed and wind direction
7. The force exerted by air molecules over a given area
8. Lines of equal pressure
9. The force which balances the vertical pressure gradient force and prevents the atmosphere around the earth from rushing off into space
10. Instrument that usually consists of three or more cups
11. An elongated high pressure area
12. Another name for a large area of low pressure observed in the middle latitudes
13. The unit of pressure most commonly found on a surface weather map
14. Surface wind that blows from land to water
15. A wind-flow pattern with a strong north-south trajectory

a. geostrophic wind
b. mid-latitude cyclone
c. wind profiler
d. anemometer
e. meridional
f. offshore wind
g. pressure gradient
h. gravity
i. wind rose
j. Coriolis force
k. ridge
l. altitude
m. millibar
n. air pressure
o. isobars
Fill in the Blank

1. The force that causes the wind to deflect (bend) to the right of its path in the Northern Hemisphere and to the left in the Southern Hemisphere is the ____________.

2. The fundamental laws of motion were formulated by this man: ____________.

3. Even though ____________ lines are drawn on a 500-millibar chart, they illustrate regions of high-and-low pressure much like isobars do.

4. A recording aneroid barometer can also be called a ____________.

5. The force that initially causes the wind to blow is the ____________ ____________.

6. At sea level, the average or standard value of atmospheric pressure is ____________ millibars, ____________ inches of mercury, and ____________ hectopascals.

7. An elongated region of low pressure is called a ____________.

8. An instrument that measures pressure but indicates altitude is the ____________.

Multiple Choice

Top

Surface

A

B

C

Figure 1

1. In Figure 1, if the air temperature is the same in each column, which column has the highest surface air pressure? (Each dot represents billions of air molecules.)
   a. column A
   b. column B
   c. column C
2. The Coriolis force is strongest when the wind speed is _____ and the latitude is _____.
   a. high, low
   b. high, high
   c. low, high
   d. low, low

3. Another name for a constant pressure chart is:
   a. isobaric map
   b. zonal map
   c. meridional map
   d. gradient map
   e. geostrophic map

4. A barometer that contains no fluid:
   a. profiler
   b. anemometer
   c. aerovane
   d. aneroid

5. Wind flow pattern that generally moves from west to east is:
   a. meridional
   b. hydrostatic
   c. zonal

6. The surface winds around an area of low pressure normally ____. Above the system, the winds normally _____.
   a. diverge, converge
   b. diverge, diverge
   c. converge, diverge
   d. converge, converge

7. In the Northern Hemisphere directly above you (at about 10,000 ft), clouds are moving from south to north, indicating a south wind. From this observation you know that the center of lowest pressure aloft must be to the _____ of you.
   a. west
   b. east
   c. north
   d. south

8. On a weather map, the strongest winds are normally observed:
   a. at the center of high pressure
   b. at the center of low pressure
   c. near a large body of water
   d. where the isobars or contour lines are close together
9. A wind that blows at a constant speed parallel to curved lines above the level of friction is called a:
   a. geostrophic wind
   b. cyclonic wind
   c. gradient wind

True-False

   1. The pressure gradient force is directed from high pressure toward lower pressure at all places on the earth.
   2. To obtain station pressure with a mercury barometer, normally you must make a correction for altitude.
   3. The Coriolis force causes the wind to blow faster.
   4. The Coriolis force is the result of horizontal differences in pressure.
   5. The winds aloft in middle latitudes of both hemispheres blow primarily from the west because the air aloft above high latitudes is colder than the air aloft above low latitudes.
   6. If the earth stopped rotating, surface winds would blow directly from higher pressure toward lower pressure.
   7. On an upper level chart (such as a 500-millibar chart), winds tend to cross the isobars or contours at an angle that averages about 30°.
   8. Cold air aloft is usually associated with low pressure and warm air aloft with high pressure.
   9. The Coriolis force is zero at the equator.
   10. As the wind moves in a curved path, the centripetal force results from an imbalance between the Coriolis force and the pressure gradient force.
   11. An instrument that indicates both wind speed and wind direction is the aerovane.
   12. Generally, the top of the friction layer (planetary boundary layer) is about 3000 ft above the surface.
   13. The air above a region of surface high pressure is normally rising.
   14. During a south wind, a wind vane will point toward the north.
   15. Atmospheric pressure decreases most rapidly in a cold column of air.
   16. The air flow around an area of high pressure is called cyclonic flow.
   17. On a weather map, closely spaced isobars or contour lines indicate a region of high winds because in this region there is a strong pressure gradient force.
18. An onshore wind blows from water onto the land.

19. An anticyclone is an area of low pressure.

Additional Questions

1. What is the approximate sea level pressure for the city in Figure 2 when its station pressure is 920 millibars? (Use a pressure change of 10 millibars per 100 meters.)

___________ millibars

2. Each of the four illustrations in Figure 3 represents the wind-flow pattern around an area of surface high or low pressure in either the Northern or Southern Hemisphere.

a. In the center of each pressure system indicate with the letter L or H whether it is a low or high pressure area.

b. In the space provided beneath each pressure system, write in whether this system is located in the Northern Hemisphere or Southern Hemisphere.
3. In Figure 4 show with arrows how the wind would blow around the area of low pressure and the area of high pressure on the upper-air chart. Both are located in the Northern Hemisphere and both are found aloft, above the level of friction. The lines around the L and H represent contour lines or isobars.

4. Answer the following questions that pertain to Figure 5, a surface weather map in the Northern Hemisphere.

a. What is the sea level pressure at point P? _________

b. At point P the wind would most likely be blowing from the _________.

c. Would the pressure gradient force at point P be directed toward the H, the L, point D, or point Q? _________

d. Would the wind at point S most likely be blowing from the southeast, southwest, northeast, or northwest? _________
e. Would you expect the strongest winds at point P, point D, or point Q? ______
   Explain.

f. Should the air above the L be rising or sinking? ______
   Should the air above the H be rising or sinking? ______

5. Answer the following questions that pertain to Figure 6, a 500-millibar chart.
   a. The solid lines on the map are contour lines, indicating elevation above sea level. Which
      contour line (A, B, or C) represents the highest pressure? ______
   b. Between contour line A and contour line B, draw arrows to show the most likely wind-
      flow pattern for the map.
   c. Is the wind direction at point 1 most likely northwest, northeast, southwest, or south-
      east? ________ Is the wind direction at point 2 most likely northwest, northeast, southwest or southeast? ________
   d. Would stronger winds be observed at point 1 or point 2? ________ Explain.
6. Express the following wind directions in terms of compass points. (Hint: see Fig. 6.23 in your textbook.)

<table>
<thead>
<tr>
<th>Wind direction (degrees)</th>
<th>Wind direction (compass points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>270°</td>
<td></td>
</tr>
<tr>
<td>360°</td>
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<tr>
<td>90°</td>
<td></td>
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<tr>
<td>225°</td>
<td></td>
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<tr>
<td>315°</td>
<td></td>
</tr>
<tr>
<td>135°</td>
<td></td>
</tr>
</tbody>
</table>

**ADDITIONAL READINGS**


Matching
1. g  5. i  9. h  13. m
2. j  6. c  10. d  14. f
3. a  7. n  11. k  15. e
4. l  8. o

Fill in the Blank
1. Coriolis force  6. 1013.25 millibars; 29.92 inches; 1013.25 hPa
2. Isaac Newton  7. trough
3. contour  8. altimeter
4. barograph  5. pressure gradient force

Multiple Choice
1. b  4. d  7. a
2. b  5. c  8. d
3. a  6. c  9. c

True-False
5. T  10. T

Additional Questions
1. 1020 millibars
2. a. low pressure area, N.H.  
   b. high pressure area, S.H.  
   c. high pressure area, N.H.  
   d. low pressure area, S.H.  
3. Around the low, the wind blows counterclockwise and parallel to the lines.  
   Around the high, the wind blows clockwise and parallel to the lines.  
4. a. 1020 millibars  
   b. northwest  
   c. the L  
   d. southeast  
   e. point P; the isobars are closer together there, producing a stronger pressure gradient force.  
   f. above the L, rising; above the H, sinking
5. a. Contour line A represents the highest altitude and also the highest pressure.
   b. The arrows should move from west to east *parallel* to the lines.
   c. at point 1, northwest; at point 2, southwest
   d. at point 1. The contour lines are closer together at point 1, which should produce stronger winds there.

6. 270°—west wind
    360°—north wind
    90°—east wind
    225°—southwest wind
    315°—northwest wind
    135°—southeast wind