Solution Manual for Exercises for Weather and Climate 8th Edition by Carbone

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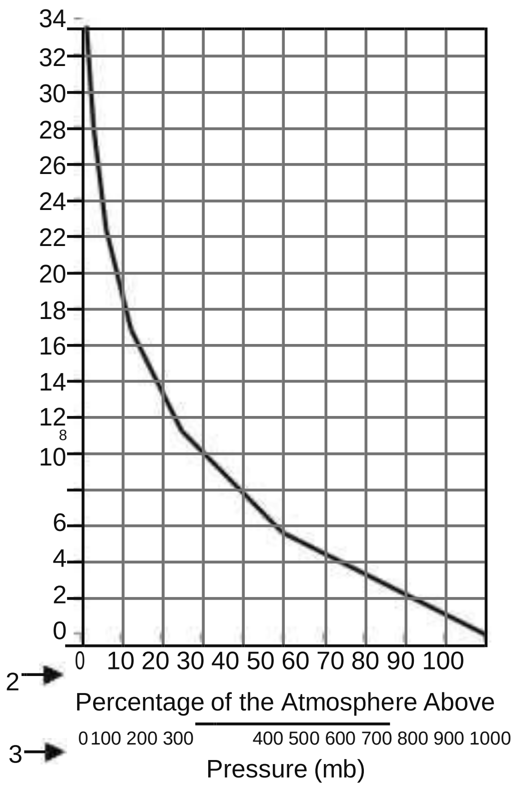
Solutions Manual to
Exercises for Weather & Climate, 8th ed.

1 *Vertical Structure of the Atmosphere*

1. Height (km) — % of atmosphere above

Height (km)	% of atmosphere above
22.4	6.25
16.8	12.5
11.2	25
5.6	50

2. & 3.



4. 25% 250 mb
   58.4% 584 mb

5. 210 mb

6. 123 mb 58.4%
   69 mb 33%

1

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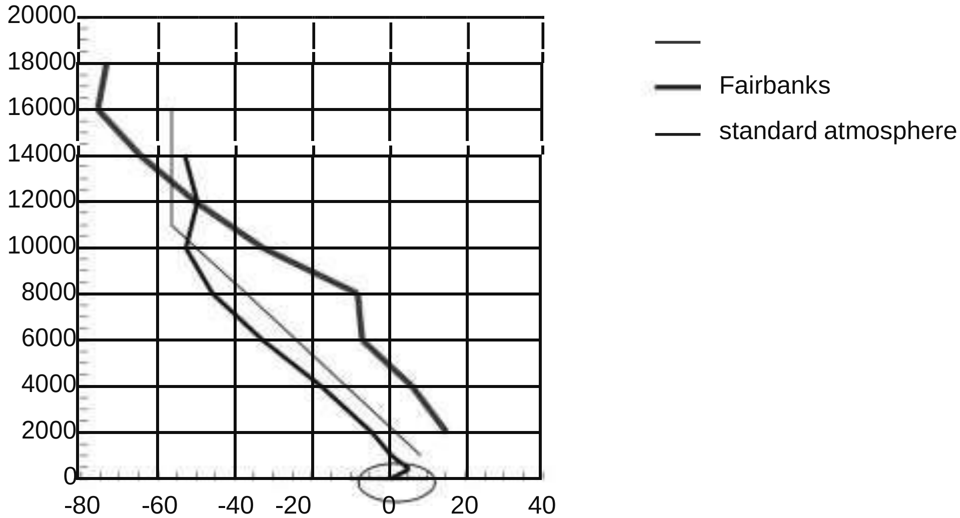
7. Ozone absorbs solar radiation (particularly in the ultraviolet portion of the electromagnetic spec-trum). This absorption leads to warming in the stratosphere.

8.

2000	4000	6000	8000	10000
2.0°C	–11°C	–24°C	–37°C	–50°C

9. & 11.



10. a. Key West b. Key West c. Fairbanks

11. See 9 above.

12. Key West tropopause: ~16,000 m, ~ –75°C; Fairbanks tropopause: ~10,000 m, ~ –53°C;

13. The greater the average temperature, the higher the tropopause. Our example suggests that vertical mixing is greater when temperature is warmer.

14. 170 mb

15. 92 mb

16. Because of greater air density in the lower layer, the pressure drop between 2 and 4 km is nearly double that between 8 and 10 km.

17. 182 mb

18. Air pressure decreases with height because there is less atmosphere to exert downward force. The pressure drop will be greatest when air density is highest because the mass of the atmosphere above decreases at a faster rate.

19. California desert: 1003.9 mb; Michigan UP: 1018.6 mb; New Brunswick: 1003.7 mb.

20. The Michigan and New Orleans stations have the same pressure (1018.6 mb), but a 30°F tempera-ture difference. The New Brunswick and southern California stations have similar low pressures (1003.7 mb and 1003.9 mb), but a 30°F temperature difference.

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21. The ideal gas law shows that pressure is proportional to the product of density times temperature. Therefore, to have a similar pressure, but be 30°F warmer, New Orleans must have a lower density.

22. The Michigan and New Brunswick stations have higher air density than the other two.

Review Questions

1. Air pressure and density decrease exponentially with height above Earth's surface. This is because gas molecules are concentrated near the surface and a given height increase at these lower levels means passing through more molecules than the same height increase at higher elevations. Temperature also decreases with height in the troposphere. This rate of decrease varies, but is typically linear compared to pressure or density.

2. The thickness of the troposphere is a function of temperature. Warmer temperatures in tropical regions create mixing to greater depths, pushing the tropopause higher.

3. The higher its relative density, the more likely air is to sink. Density is influenced by temperature and pressure. At the low pressure of the mid and upper troposphere, density is lower than it is at lower elevations.

4. Pressure changes much faster vertically than it does horizontally. It drops 100 mb in the lowest kilometer of the atmosphere.

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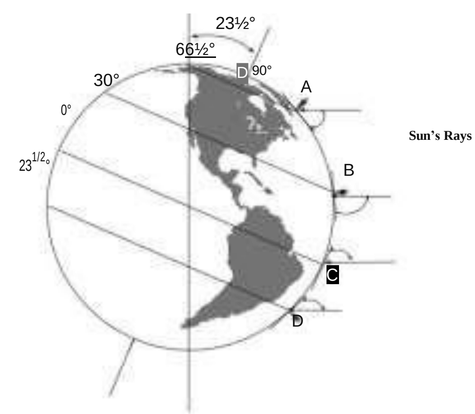
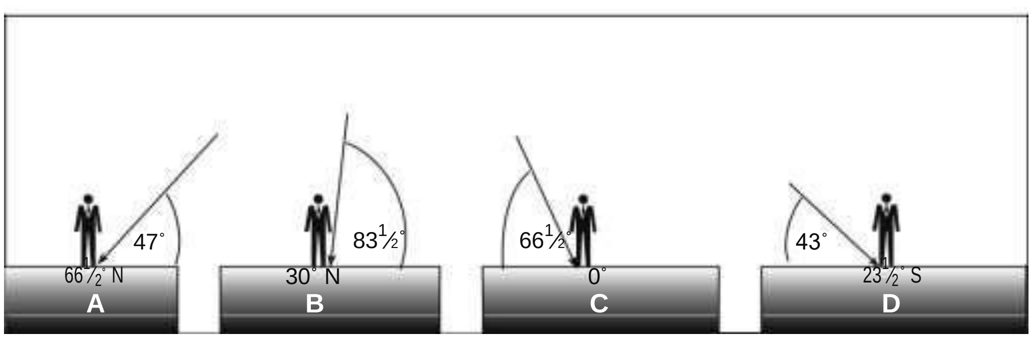
2 *Earth–Sun Geometry*

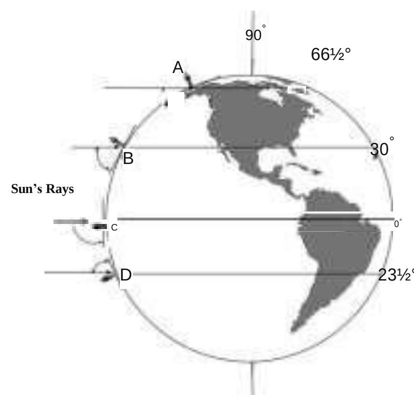
1. June 21





June 21 profile view

March 21



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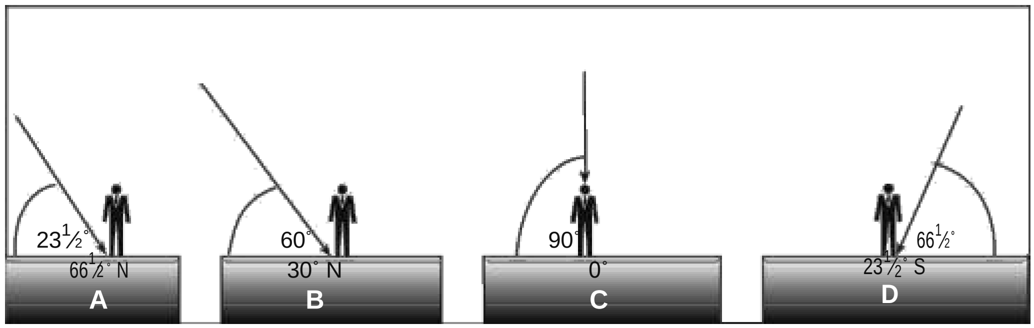

March 21 profile view

2. $63\frac{1}{2}°$; December 21

3. $26\frac{1}{2}°$

4. a. 0° (equator)
   b. $23\frac{1}{2}°$ N
   c. 0° (equator)
   d. $23\frac{1}{2}°$ S
   e. [variable]

5.

	New Orleans	Helsinki
a.	60°	30°
b.	$83\frac{1}{2}°$	$53\frac{1}{2}°$
c.	60°	30°
d.	$36\frac{1}{2}°$	$6\frac{1}{2}°$
e.	[variable]	[variable]

6. [variable]

7. Answer is date dependent. Example for 34° N latitude on February 1, a two-meter pole casts a shadow measuring 2.52 meters.

$$\tan \Theta = \frac{(\textit{length of pole})}{(\textit{length of shadow})}$$

$$\Theta = \tan^{-1}(0.7937)$$

$$\Theta = 38.44°$$

8. [variable]

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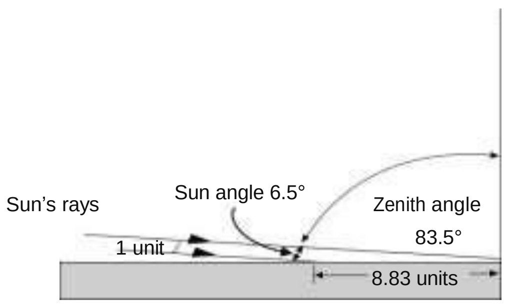
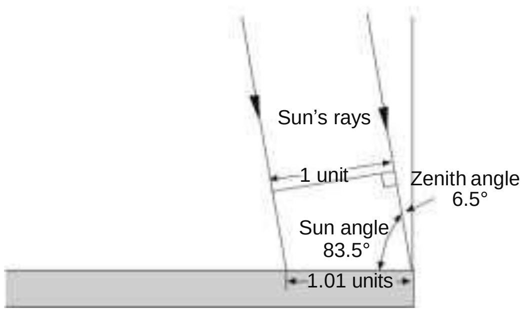
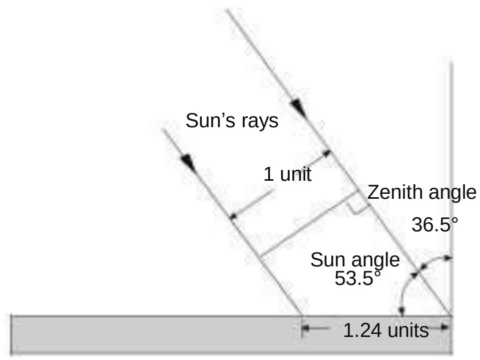
9. 60° N Dec. 22



30° N June 21



60° N June 21



10. Summer temperature is highest because solar radiation is more concentrated. During the winter, it's cooler as the solar beam is spread over a greater surface area.

11. There is a much greater seasonal range in daylight hours in polar regions than in tropical regions.

12.

	30° N	60° N
June solstice	14	18
Equinoxes	12	12
December solstice	10	6

13. 60° N

14. The change in daylight hours is greatest near the equinoxes (when solar declination changes are greatest) and smallest near the solstices.

15. a. At 30° N, the sun rises due east and sets due west on the equinoxes. Between the March and September equinoxes, it rises slightly north of east and sets slightly north of west. Between the September and March equinoxes, it rises slightly south of east and sets slightly south of west.

b. The same general pattern is found at 60° N, but it is more extreme. In fact, the figure shows that on the June solstice the sun rises just north of NE (45°) and sets just north of NW (315° N). On the December solstice, the sun rises just south of SE (135°) and sets just south of SW (225°).

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16. March 21: 500 Wm^{-2} September 22: 500 Wm^{-2}

June 21: 349 Wm^{-2} December 22: 658 Wm^{-2}

17. The seasonal difference in solar intensity (beam spreading) and daylight hours is greater at 60° N than at 30° N.

18. The difference in beam spreading between 60° N and 30° N is greater in winter. Furthermore, 60° N has a shorter daylight period than 30° N in winter, while in summer the daylight hours are actually greater at 60° N.

19. [variable}

20. Most direct rays: 1 unit beam = 1.000 surface units; Date March 21, September 22
Least direct rays: 1 unit beam = 1.090 surface units; Date June 21, December 21

21. 9%

22. [variable]

23. [variable]

24. The higher the latitude, the greater the seasonal range in solar intensity. This results in a larger annual temperature range at high latitudes than in the tropics.

25.

	December Solstice	June Solstice
60° N	8.834	1.244
50° N	3.521	1.117
40° N	2.241	1.043
30° N	1.681	1.006
20° N	1.379	1.002

26. The solar intensity gradient across the mid-latitudes is much greater in winter and contributes to a greater temperature gradient.

Review Questions

1. A given change at low sun angles is much more effective than the same change at higher sun angles. Therefore, the seasonal shift of sun angle from 36.5° to 83.5° at New Orleans results in less change in solar intensity than the shift from 6.5° to 53.5° at Helsinki.

2. A greater range in solar intensity and daylight hours will result in a greater range in solar radiation received and temperature.