

Solutions manual for Exercises for Weather & Climate, 8th ed.title page

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

<b>1</b>	Vertical Structure of the Atmosphere	1
<b>2</b>	Earth–Sun Geometry	4
<b>3</b>	The Surface Energy Budget	8
<b>4</b>	The Global Energy Budget	10
<b>5</b>	Atmospheric Moisture	12
<b>6</b>	Saturation and Atmospheric Stability	16
<b>7</b>	Cloud Droplets and Raindrops	19
<b>8</b>	Atmospheric Motion	21
<b>9</b>	Weather Map Analysis	28
<b>10</b>	Mid-Latitude Cyclones	33
<b>11</b>	Weather Forecasting	37
<b>12</b>	Thunderstorms and Tornadoes	43
<b>13</b>	Hurricanes	46
<b>14</b>	Climate Controls	50
<b>15</b>	Climate Classification	53
<b>16</b>	Climatic Variability and Change	55
<b>17</b>	Simulating Climatic Change	58
<i>Appendix A</i>	Dimensions and Units	60
<i>Appendix B</i>	Earth Measures	62
<i>Appendix C</i>	GeoClock	63

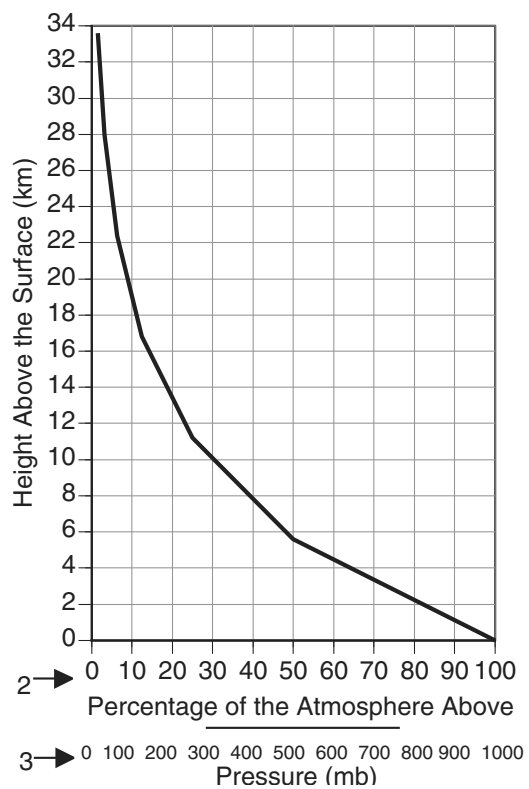


# 1 Vertical Structure of the Atmosphere

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

2. & 3.

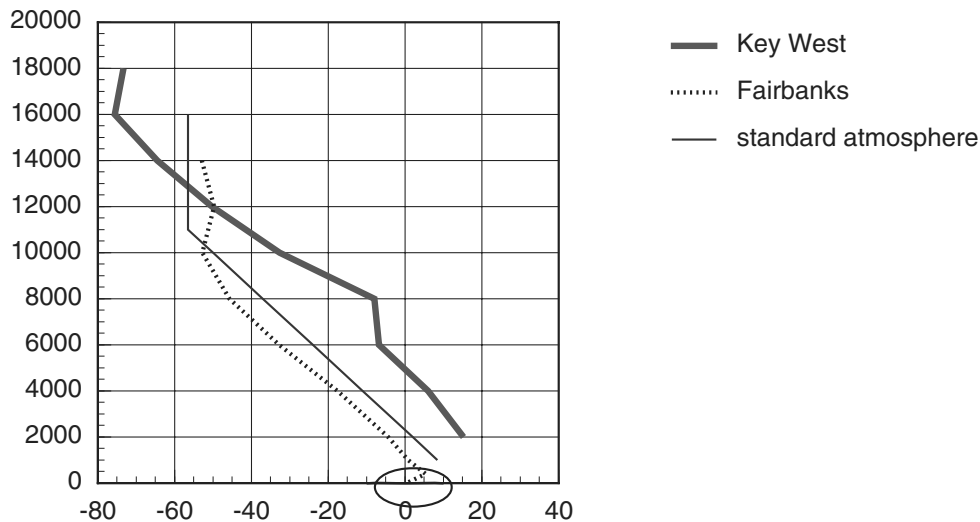


4.	25%	250 mb
	58.4%	584 mb
5.	210 mb	
6.	123 mb	58.4%
	69 mb	33%

7. Ozone absorbs solar radiation (particularly in the ultraviolet portion of the electromagnetic spectrum). 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 temperature 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.

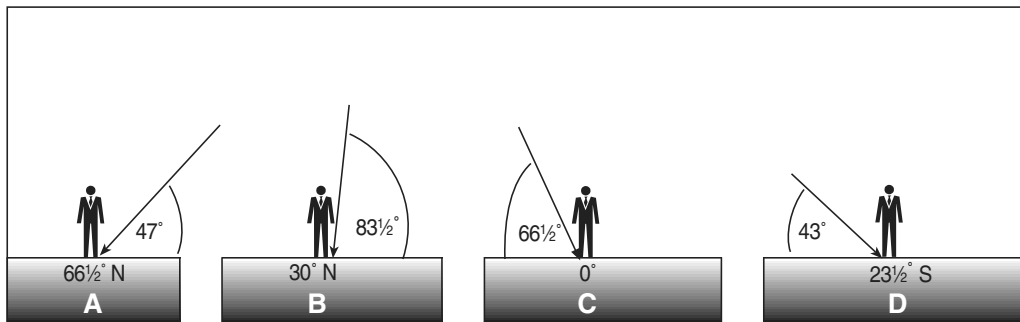
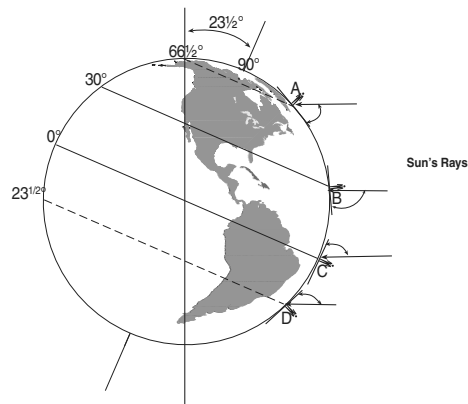
21. The ideal gas law shows that pressure is proportional to the product of density times temperature. Therefore, to have a similar pressure, but be 30°F warmer, New Orleans must have a lower density.
22. The Michigan and New Brunswick stations have higher air density than the other two.

#### **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.

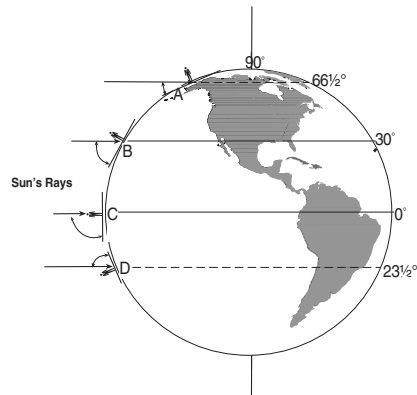
## 2 Earth–Sun Geometry

1. June 21

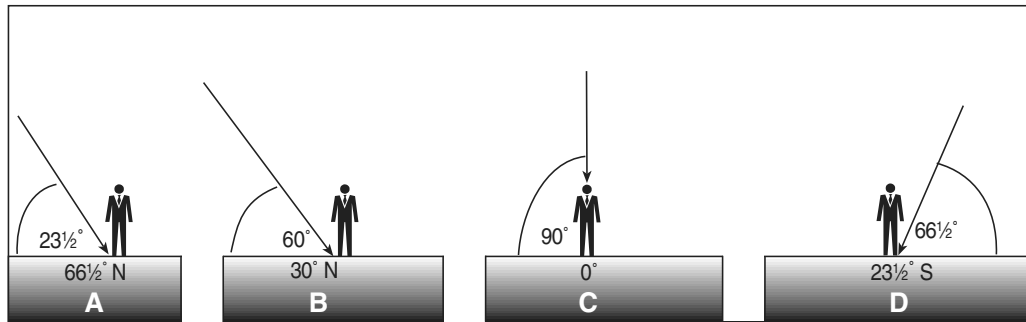


June 21 profile view

March 21







March 21 profile view

2.  $63\frac{1}{2}^\circ$ ; December 21
3.  $26\frac{1}{2}^\circ$
4.
  - a.  $0^\circ$  (equator)
  - b.  $23\frac{1}{2}^\circ$  N
  - c.  $0^\circ$  (equator)
  - d.  $23\frac{1}{2}^\circ$  S
  - e. [variable]
5. 
 

	New Orleans	Helsinki
a.	$60^\circ$	$30^\circ$
b.	$83\frac{1}{2}^\circ$	$53\frac{1}{2}^\circ$
c.	$60^\circ$	$30^\circ$
d.	$36\frac{1}{2}^\circ$	$6\frac{1}{2}^\circ$
e.	[variable]	[variable]
6. [variable]
7. Answer is date dependent. Example for  $34^\circ$  N latitude on February 1, a two-meter pole casts a shadow measuring 2.52 meters.

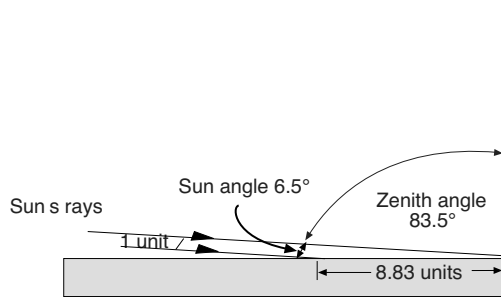
$$\tan \Theta = \frac{(\text{length of pole})}{(\text{length of shadow})}$$

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

$$\Theta = 38.44^\circ$$

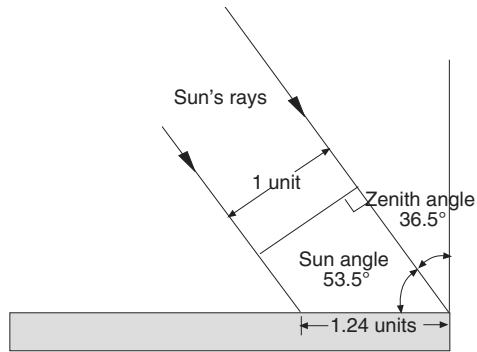
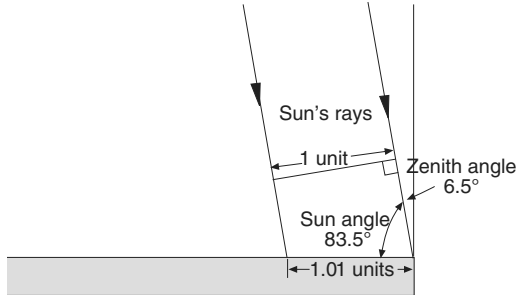
8. [variable]

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°).

16. March 21:  $500 \text{ Wm}^{-2}$       September 22:  $500 \text{ Wm}^{-2}$   
       June 21:  $349 \text{ Wm}^{-2}$       December 22:  $658 \text{ Wm}^{-2}$
17. The seasonal difference in solar intensity (beam spreading) and daylight hours is greater at  $60^\circ \text{ N}$  than at  $30^\circ \text{ N}$ .
18. The difference in beam spreading between  $60^\circ \text{ N}$  and  $30^\circ \text{ N}$  is greater in winter. Furthermore,  $60^\circ \text{ N}$  has a shorter daylight period than  $30^\circ \text{ N}$  in winter, while in summer the daylight hours are actually greater at  $60^\circ \text{ N}$ .
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 |
|----------------------|-------------------|---------------|
| $60^\circ \text{ N}$ | 8.834             | 1.244         |
| $50^\circ \text{ N}$ | 3.521             | 1.117         |
| $40^\circ \text{ N}$ | 2.241             | 1.043         |
| $30^\circ \text{ N}$ | 1.681             | 1.006         |
| $20^\circ \text{ N}$ | 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  $36.5^\circ$  to  $83.5^\circ$  at New Orleans results in less change in solar intensity than the shift from  $6.5^\circ$  to  $53.5^\circ$  at Helsinki.
2. A greater range in solar intensity and daylight hours will result in a greater range in solar radiation received and temperature.