NAME ______________________ Lab 3.

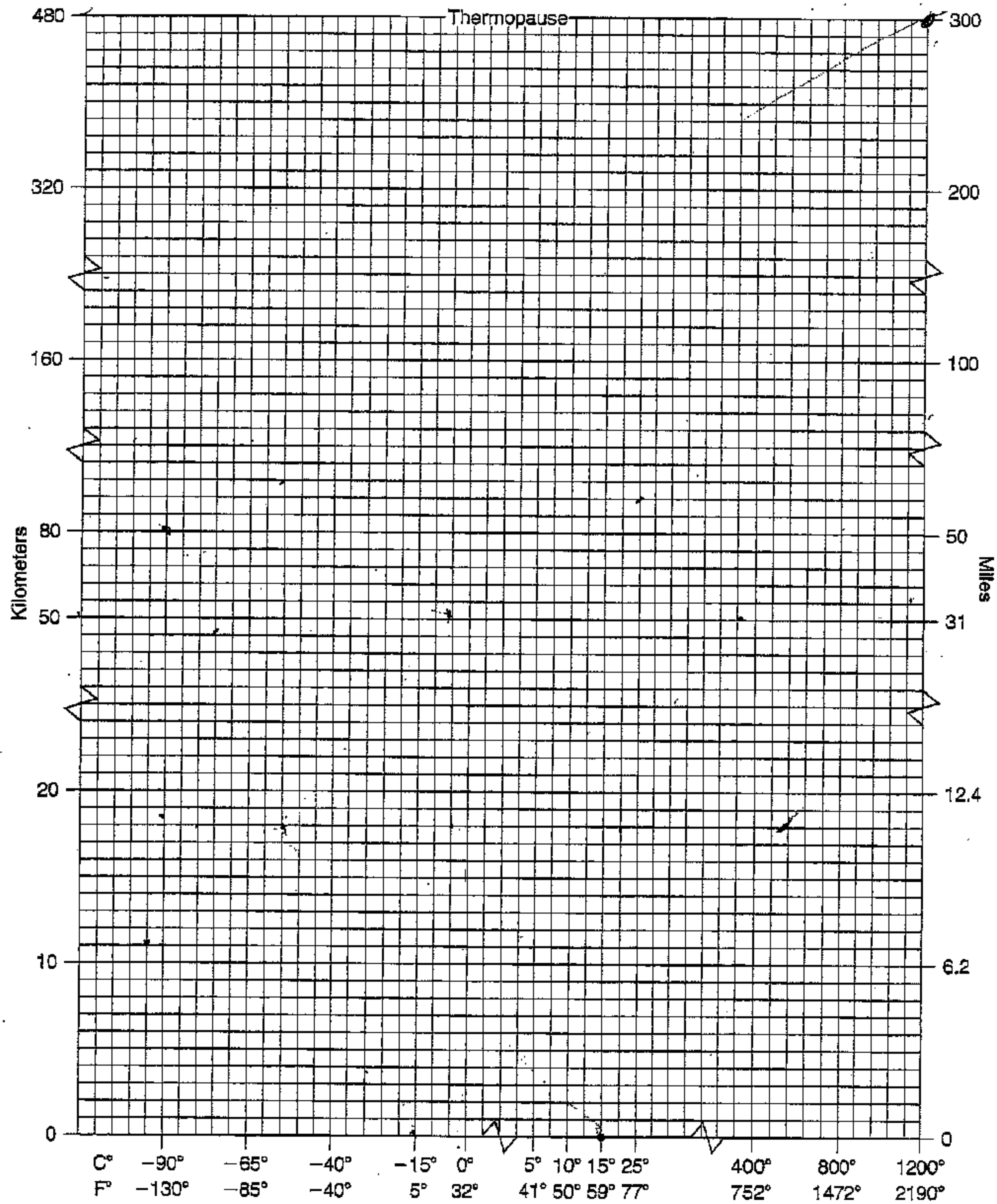


Figure 6.1
Atmospheric temperature profile graph - should look similar to Figure 3.3a p.64, ch.3.
Directions on next page →

Temperature Profile of the Atmosphere

Based on *temperature*, the atmosphere is divided into four distinct zones or layers: the **thermosphere, mesosphere, stratosphere**, and **troposphere**. The transition area at the top of each temperature region is named using the suffix *-pause*, which means "to cause to change," i.e., **thermopause, mesopause, stratopause**, and **tropopause.**

Temperatures in the lower atmosphere do not simply decline with altitude, for it is more complex than this and actually varies. In the upper atmosphere the temperature profile shows that temperatures rise sharply in the thermosphere, up to 1200°C (2200°F) and higher. However, we must use different concepts of "temperature" and "heat" to understand this effect. The intense radiation in this portion of the atmosphere excites individual molecules (nitrogen and oxygen) and atoms (oxygen) to high levels of vibration. This **kinetic energy**, the energy of motion, is the vibrational energy stated as "temperature." However, the density of the molecules is so low that little actual heat is produced. Heating in the lower atmosphere near Earth's surface differs because the greater number of molecules in the denser atmosphere transmit their kinetic energy as **sensible heat**, meaning that we can sense it and measure it. Figure 6.1 gives you the general trend for this temperature profile that you specifically plot in this section using data from Table 6.1.

Table 6.1
Standard temperature values for the atmosphere

Altitude	Altitude	Temperature
Surface (No. Hemis.)	Sea level	15° C (59°F)
Tropopause	18 km (11 mi)	−57°C (−70°F)
[Isothermal layer]	[11 to 25 km]	
Stratopause	50 km (31 mi)	0°C (32°F)
Mesopause	80 km (50 mi)	−90°C (−130°F)
Thermopause	480 km (300 mi)	1200°C (2200°F)+

↑T but not sensible

See p. 64 Fig. 3.3a

1. Using the graph in Figure 6.1, plot the standard temperature values given in Table 6.1 (the sea level value has been done for you). After you plot the data points, connect them with a line graph to complete the profile. Label the layers of the atmosphere and the transition areas at the top of each layer.

2. Briefly explain what physical properties produce a temperature decrease with altitude in the troposphere (at the normal lapse rate). ______________________________

____

____

3. Why do temperatures increase throughout most of the stratosphere? Specifically discuss the process that produces this warming effect. ______________________________

____

____

4. After consulting the appropriate sections of a physical geography textbook, briefly describe the predicament relative to stratospheric ozone: identification and history of the problem, causes, current actions being taken, and present status. ______________________________

____

____

____

____

1. Using the temperature graphs provided in Figure 6.2 plot the data from Table 6.2 for these two cities. Use a smooth curved *line graph* to portray the temperature data. Calculate the *mean* (average) *annual temperature* and the *temperature range* (difference between the highest and lowest) for each city. Fill in the other information asked for on the climograph from information given in the table.

Table 6.2
Temperature data for La Paz and Concepción, Bolivia.

La Paz, Bolivia: pop. 993,000, lat. 16°30′ S, long. 68°10′ W, elev. 4103 m (13,461 ft).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temp. °C	9.0	9.0	9.0	9.0	8.0	7.0	8.0	8.0	9.0	10.0	10.0	10.0	9.0
(°F)	(48.2)	(48.2)	(48.2)	(48.2)	(46.4)	(44.6)	(46.4)	(46.4)	(48.2)	(50.0)	(50.0)	(50.0)	(48.2)

Concepción, Bolivia: pop. 10,000, lat. 16°15′ S, long. 62°03′ W, elev. 490 m (1608 ft).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temp. °C	25.0	26.0	25.0	24.0	23.0	19.0	22.0	24.0	27.0	27.0	26.0	26.0	25.0
(°F)	(77.0)	(78.8)	(77.0)	(75.2)	(73.4)	(66.2)	(71.6)	(75.2)	(80.6)	(80.6)	(78.8)	(78.8)	(77.0)

La Paz, Bolivia

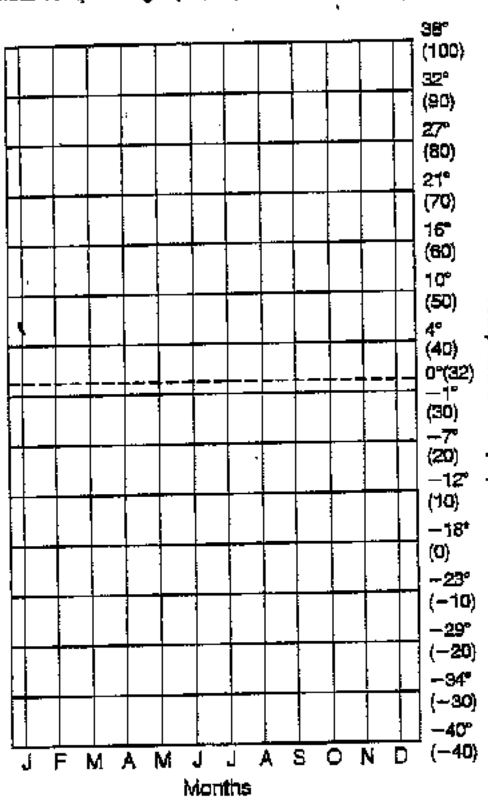
Latitude: ____________ Longitude: ____________

Elevation: ________ m ________ ft

Population: ______________

Avg. Annual Temperature (°C, °F): ______________

Annual Temp. Range (°C, °F): ______________



Concepción, Bolivia

Latitude: ____________ Longitude: ____________

Elevation: ________ m ________ ft

Population: ______________

Avg. Annual Temperature (°C, °F): ______________

Annual Temp. Range (°C, °F): ______________

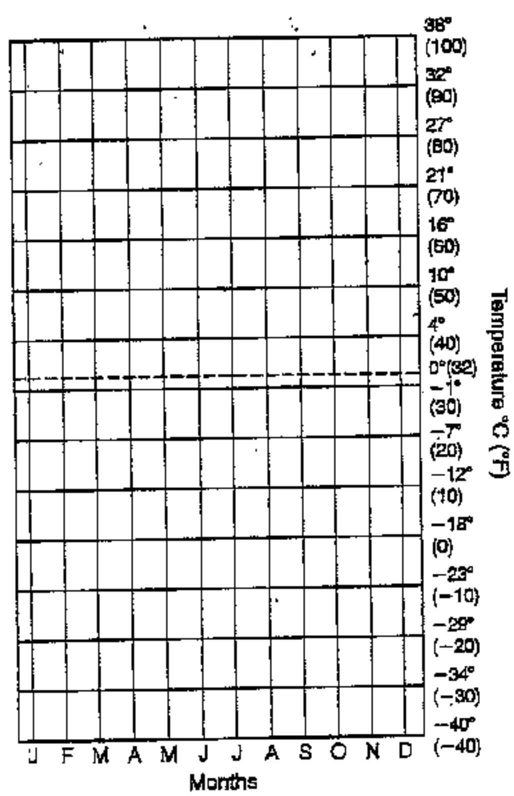


Figure 6.2
Temperature graphs for La Paz and Concepción, Bolivia.

Vancouver, British Columbia

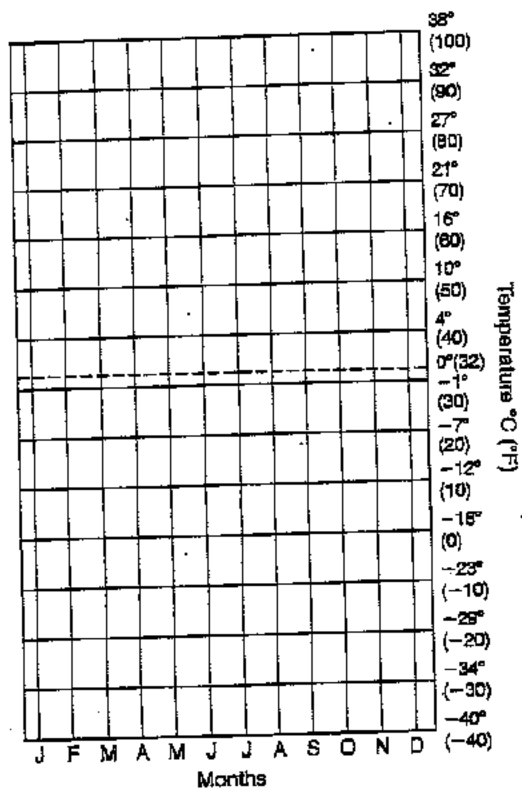
Latitude: __________ Longitude: __________

Elevation: ________m __________ft

Population: ____________

Avg. Annual Temperature (°C, °F): ______________

Annual Temp. Range (°C, °F): ______________



Winnipeg, Manitoba

Latitude: __________ Longitude: __________

Elevation: ________m __________ft

Population: ____________

Avg. Annual Temperature (°C, °F): ______________

Annual Temp. Range (°C, °F): ______________

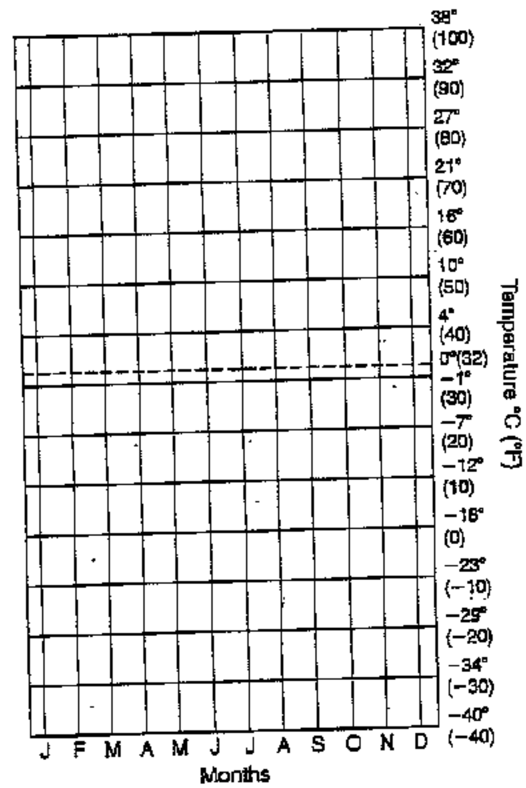


Figure 6.3
Temperature graphs for Vancouver, British Columbia, and Winnipeg, Manitoba, Canada.

1. Using the data given in Table 6.3 plot the temperatures for these two cities and portray with a smooth curved *line graph* on the temperature graph in Figure 6.3. Fill in the other information asked for from data given in the table.

Table 6.3
Temperature data for Vancouver, British Columbia, and Winnipeg, Manitoba, Canada.

Vancouver, British Columbia : pop. 431,000, lat. 49°11′ N, long. 123°10′ W, elev. sea level.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temp. °C	3.3	4.4	5.6	7.8	10.0	12.2	13.9	14.4	12.2	9.4	6.7	4.4	8.7
(°F)	(37.9)	(39.9)	(42.1)	(46.0)	(50.0)	(54.0)	(57.0)	(57.9)	(54.0)	(48.9)	(44.1)	(39.9)	(47.7)

Winnipeg, Manitoba: pop. 561,000, lat. 49°54′ N. long. 97°14′ W, elev. 248 m (813.6 ft).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temp. °C	−19.4	−16.7	−8.9	3.3	11.1	16.7	19.4	17.8	12.2	5.0	−5.6	−14.4	1.7
(°F)	(−2.9))	(1.9)	(16.0)	(37.9)	(52.0)	(62.1)	(66.9)	(64.0)	(54.0)	(41.0)	(21.9)	(6.1)	(35.1)

✻ SECTION 4

Altitude and Temperature

Within the troposphere, temperatures decrease with increasing altitude above Earth's surface: the **normal lapse rate** of temperature change with altitude is 6.4C°/1000 m or 3.5F°/1000 ft. Worldwide, mountainous areas experience lower temperatures than do regions nearer sea level, even at similar latitudes. The consequences are that average air temperatures at higher elevations are lower, nighttime cooling increases, and the temperature range between day and night and between areas of sunlight and shadow also increases. Temperatures may decrease noticeably in the shadows and shortly after sunset. Surfaces both gain heat rapidly and lose heat rapidly to the thinner atmosphere.

As we observed in Lab Exercise 5, the distribution of intercepted solar energy exhibits an overall imbalance among equatorial, midlatitude, and polar locations. The equatorial regions exceed the polar regions by 2.5 times in terms of insolation received. As an interesting example of the effects of altitude, let's examine two cities in Bolivia, La Paz and Concepción.

Temperature data are presented in Table 6.2 for La Paz and Concepción. Both stations are approximately the same distance south of the equator but differ in elevation. La Paz is at 4103 m (13,461 ft), whereas Concepción is at 490 m (1608 ft) above sea level. The hot, humid climate of Concepción at its much lower elevation stands in marked contrast to the cool, dry climate of highland La Paz.

People living around high-altitude La Paz actually grow wheat, barley, and potatoes—crops characteristically grown in the cooler midlatitudes at lower elevations. These crops do well despite the fact that La Paz is 4103 m above sea level. The combination of *elevation* (moderating temperatures) and *equatorial location* (producing higher Sun altitude and consistent daylength) guarantee La Paz these temperature conditions, averaging about 9°C (48°F) for every month. Such moderate temperature and moisture conditions lead to the formation of more fertile soils than those found in the warmer, wetter climate of Concepción.

✻ SECTION 5

Marine versus Continental Effects

The irregular arrangement of landmasses and water bodies on Earth contributes to the overall pattern of temperature. The physical nature of the substances themselves—rock and soil versus water—is the reason for these **land-water heating differences.** More moderate temperature patterns are associated with water bodies compared to more extreme temperatures inland.

These contrasts in temperatures are the result of the land-water temperature controls: evaporation, transmissibility, specific heat, movement, ocean currents, and sea-surface temperatures. The term **marine,** or *maritime*, is used to describe locations that exhibit the moderating influences of the ocean, usually along coastlines or on islands. **Continentality** refers to the condition of areas that are less affected by the sea and therefore have a greater range between maximum and minimum temperatures diurnally (daily) and yearly.

The Canadian cities of Vancouver, British Columbia, and Winnipeg, Manitoba, exemplify these marine and continental conditions. Both cities are at approximately 49° N latitude. Respectively, they are at sea level and 248 m (814 ft) elevation. However, Vancouver has a more moderate pattern of average maximum and minimum temperatures than Winnipeg. Vancouver's annual range of 11.1 C° (20.0 F°) is far below the 38.8 C° (70.0 F°) temperature range in Winnipeg. In fact, Winnipeg's continental temperature pattern is more extreme in every aspect than that of maritime Vancouver.

See p. 112-117. Ch.5 to help you answer these.

2. Why are the temperatures at La Paz more moderate (tending toward average, i.e., less extreme) in every month and so consistent overall as compared to Concepción? ______

______

______

______

3. Recall that the *normal lapse rate* of temperature change with altitude is 6.4C°/1000 m or 3.5F°/1000 ft. Calculate the difference in altitude between La Paz and Concepción, and compare the difference in their *mean (average) annual temperatures*. Is the difference between the mean annual temperatures for these two cities higher, lower, or the same as that produced by calculating average normal lapse rate conditions? (Show your work.) ______

______

______

4. The annual march of the seasons and the passage of the subsolar point between the tropics of Cancer and Capricorn affect these stations. Can you detect from your temperature graphs these seasonal effects? Explain.

______

______

2. Compare and contrast the marine temperature regime of Vancouver with the continental regime of Winnipeg. What significant differences do you note? ______

______

______

3. How many months register average temperatures below freezing in Winnipeg? ______

How many months average below freezing in Vancouver? ______

Explain. ______

______

6

* SECTION 8

The Temperatures We Feel

Our perception of temperature is described by the terms **apparent temperature,** or *sensible temperature.* The combination of water vapor content, wind speed, and air temperature affect each individual's sense of comfort. High temperatures, high humidity, and low winds produce the most heat discomfort, whereas low humidity and strong winds enhance cooling sensation and effect (due to the increased evaporation of moisture from the skin). The wind chill index is important to those who experience (live through) winters with freezing temperatures. The NWS and the Meteorological Services of Canada (MSC, **http://www.msc-smc.ec.gc.ca/contents_e.html/**) revised the wind chill formula and standard assumptions and introduced a new wind-chill chart during the 2001–2002 winter season. The new Wind Chill Temperature (WCT) Index is an effort to improve the accuracy of heat loss calculations.

A wind-chill chart of estimated values is presented in Figure 6.8 in both metric and English units. The *wind chill factor* indicates the enhanced rate at which body heat is lost to the air. As wind speeds increase, heat loss from the skin increases. For example, if the air temperature is −1°C (30°F) and the wind is blowing at 32 kmph (20 mph), skin temperatures will be −8°C (17°F).

See Figure 5.2 p.108 in textbook for a better image.

Actual Air Temperature in °C (°F)

Wind speed, kmph (mph)									
Calm	4° (40°)	−1° (30°)	−7° (20°)	−12° (10°)	−18° (0°)	−23° (−10°)	−29° (−20°)	−34° (−30°)	−40° (−40°)
8 (5)	2° (36°)	−4° (25°)	−11° (13°)	−17° (1°)	−24° (−11°)	−30° (−22°)	−37° (−34°)	−43° (−46°)	−49° (−57°)
16 (10)	1° (34°)	−6° (21°)	−13° (9°)	−20° (−4°)	−27° (−16°)	−33° (−28°)	−41° (−41°)	−47° (−53°)	−54° (−66°)
24 (15)	0° (32°)	−7° (19°)	−14° (6°)	−22° (−7°)	−28° (−19°)	−36° (−32°)	−43° (−45°)	−50° (−58°)	−57° (−71°)
32 (20)	−1° (30°)	−8° (17°)	−16° (4°)	−23° (−9°)	−30° (−22°)	−37° (−35°)	−44° (−48°)	−52° (−61°)	−59° (−74°)
40 (25)	−2° (29°)	−9° (16°)	−16° (3°)	−24° (−11°)	−31° (−24°)	−38° (−37°)	−46° (−51°)	−53° (−64°)	−61° (−78°)
48 (30)	−2° (28°)	−9° (15°)	−17° (−1°)	−24° (−12°)	−32° (−26°)	−39° (−39°)	−47° (−53°)	−55° (−67°)	−62° (−80°)
56 (35)	−2° (28°)	−10° (14°)	−18° (0°)	−26° (−14°)	−33° (−27°)	−41° (−41°)	−48° (−55°)	−56° (−69°)	−63° (−82°)
64 (40)	−3° (27°)	−11° (13°)	−18° (−1°)	−26° (−15°)	−34° (−29°)	−42° (−43°)	−49° (−57°)	−57° (−71°)	−64° (−84°)
72 (45)	−3° (26°)	−11° (12°)	−19° (−2°)	−27° (−16°)	−34° (−30°)	−42° (−44°)	−50° (−58°)	−58° (−72°)	−66° (−86°)
80 (50)	−3° (26°)	−11° (12°)	−19° (−3°)	−27° (−17°)	−35° (−31°)	−43° (−45°)	−51° (−60°)	−59° (−74°)	−67° (−88°)

Frostbite times: 30 min. 10 min. 5 min.

Frostbite Times: 30 min 10 min 5 min 10 min 5 min

Figure 6.8
Wind chill chart for various temperatures and wind velocities.

7

Ch. 5

see P. 108-109/1 to help you answer these questions

1. How does wind enhance the loss of heat from exposed skin? ______

______

______

2. Describe the difference between a cotton (loose-weave) jacket and a nylon windbreaker (tight-weave) jacket relative to the wind-chill concept. Which prevents the wind access to your skin more effectively? ______

______

______

3. Use the wind-chill chart in Figure 6.8 to determine the wind-chill temperature for each of the following examples:

°C (°F)

a) Wind speed: 24 kmph, air temperature: −34°C = wind-chill temp: ______

b) Wind speed: 48 kmph, air temperature: −7°C = wind-chill temp: ______

c) Wind speed: 8 kmph, air temperature: +4°C = wind-chill temp: ______

d) Wind speed: 56 kmph, air temperature: −23°C = wind-chill temp: ______

4. Competitive downhill ski racers are subjected to severe wind chill, as are average skiers and snowboarders to a lesser degree. Assuming a downhill racer is going 80 kmph (50 mph), which is coasting on some runs, and the air temperature is −18°C (0°F), what is the wind chill they are feeling on any exposed skin? ______

What is their time to experience frostbite given these conditions? ______. In televised coverage, what kind of outfits do these racers wear for protection? ______

______

______

______