Homework–Module 1 Name:

1) Warning signs such as the one to the right are common before bridges. And they are put there for good reason.

Why does the bridge get icy before the pavement on the ground when air temperatures drop below freezing? Use heat transfer concepts of Chapter 4 to explain your answer. Assume calm winds to simplify the discussion.

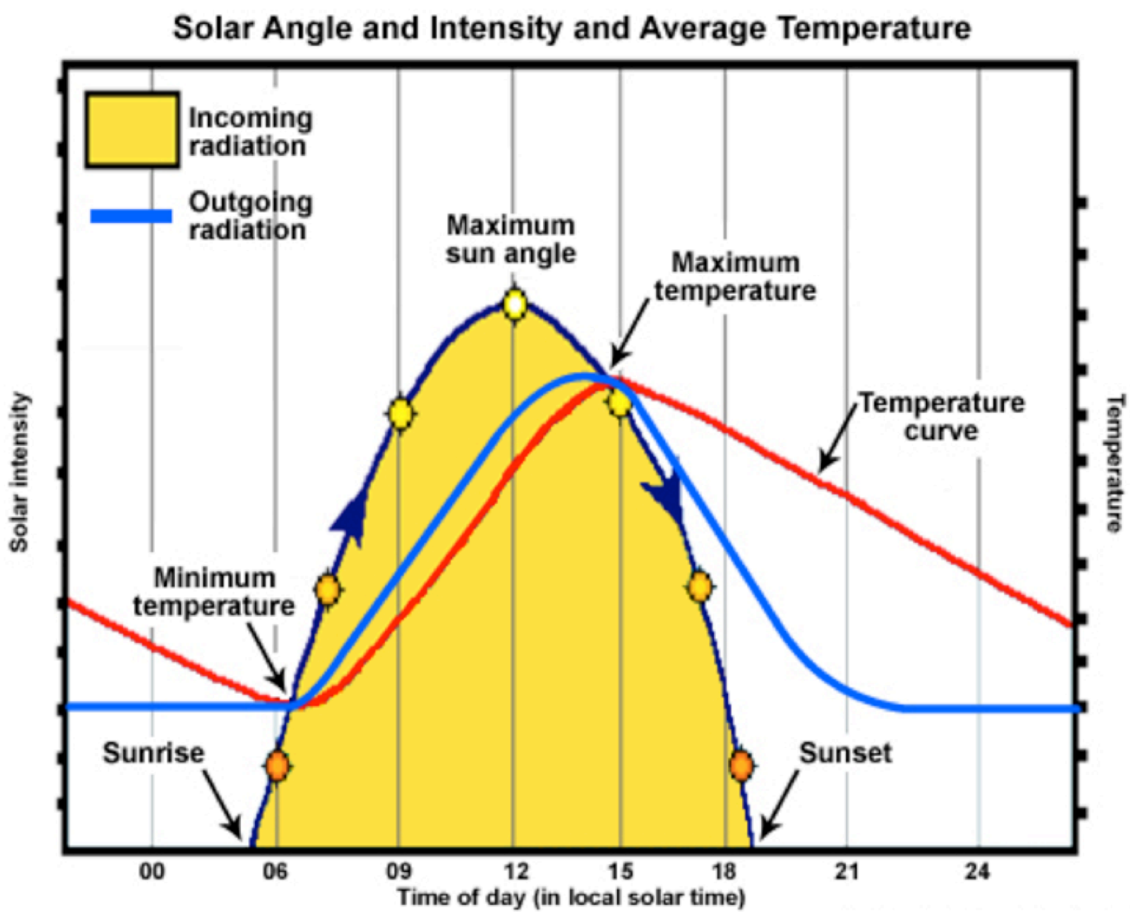
There is a 600-character limit for all questions.

2) One of my most humbling experiences as a young meteorologist (a.k.a. early learning experiences) occurred for Corvallis, Oregon during the winter of 1979-80. I forecast clear, calm conditions overnight with a low near freezing (33˚F). It was indeed calm all night with cold air trapped in the Willamette Valley. And it was clear too…most of the night. Unfortunately for my forecast, low-clouds (stratocumulus) began to drift overhead after midnight, at which time the temperature warmed to the mid-forties Fahrenheit and stayed there through the rest of the night. My forecast low ended up 8˚F too cold, a major bust!

Use heat transfer concepts to explain why the surface temperature increased as the low clouds moved overhead. (Hint: Subsection 4.5.4 and Fig. 4.15 of H&P on how clouds impact the absorption of IR radiation.)

3) I used to show in lecture sections the schematic to explain the diurnal cycle of temperature in terms of radiative balance. Unfortunately, the diagram has a conceptual error (that I intentionally omitted during the narrative for pedagogic reasons) where two of the curves are not consistent with the laws of radiation. Which two curves are in error? Use the laws of radiation to explain what the inconsistency is between the two curves and what changes need to be made to correct the diagram. (Note: The COMET Program has since corrected the figure.)

(Hint: Radiation Laws of Box 4.1 and subsection 4.5.3 of H&P.)



Black curve-incoming solar radiation
Blue curve-outgoing IR radiation
Red curve-temperature

4) Every thermometer of the National Weather Service is placed inside a standardized weather shelter that is painted white, provides shade at all times, is ventilated, and is placed two meters above ground level (AGL). See picture to the right. Answer the following questions regarding differences in the daily MAX and MIN temperatures if the thermometer placement is changed as described. Assume clear, calm, cloudless weather for each question.

Thermometer in a shelter. (Hakim & Patoux, 2018).

a) Explain how MAX temperature readings would change if the thermometer was not placed in the shade?

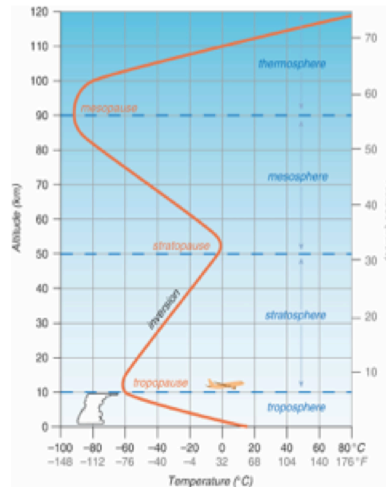
b) Explain how MAX and MIN temperature readings would change if the shelter was painted black, not white?

c) Explain how MAX and MIN temperature readings would change if the shelter was airtight, not ventilated?

d) Explain how MAX and MIN temperature readings would change if the shelter was 2 inches AGL, not 2 meters?

5) Pressure (with rare exceptions beyond the level of this course) always decreases with elevation gain. Explain why temperatures increase with altitude in the stratosphere when the troposphere is mainly heated from below by the earth's surface.

(Hint: Section 3.5 of H&P.)



Average vertical temperature profile (Hakim & Patoux, Fig. 3.3)

Use heat transfer concepts to answer the next two questions. Assume you are wearing the same clothing for every situation.

6) On a cold calm day, why would you feel warmer (heat more rapidly) at noon on a clear sunny day than you would on an overcast day when the air temperature is the same? (Hint: search *wet-bulb globe temperature*.)

7) During a very cold, calm, winter night, why would you feel colder (cool more rapidly) near sea level (e.g. 10 meters) than at a high elevation site like a ski resort (3000 meters) when the air temperatures are the same?

8) Hakim & Patoux state (Box 2.2, p.24) that a "good rule of thumb is that pressure decreases by about 8 hPa (mb) every 60 m of elevation with each 60 m gain in altitude (at low elevation) when adjusting station pressures to mean sea level (MSL). But what does "at low elevation" mean? Let's explore how robust the "rule of thumb" of H&P is for sites in the western U.S. at high elevations.

a) Station pressures at Tucson International Airport (KTUS), at an elevation of 806 m (2643'), have an average value of 917 hPa in July and 924 hPa in January. What would be the pressure if adjusted to MSL using a correction of 8 hPa per 60 m? Remember to include units of pressure with your answers.

b) The answers that you get using an adjustment of 8 hPa every 60 m should be significantly higher than the actual averages of SLP at KTUS of 1010 hPa in July and 1017 hPa in January. Use these actual values of SLP to derive an adjustment factor that would be more appropriate for KTUS in July and January.

c) Station pressures at Denver International Airport (KDEN at an elevation of 1650 m, 5414') range from an average near 838 hPa in January to near 832 hPa in July. The average SLP at KDEN is close to 1018 hPa in January and 1012 hPa July. Use these actual averages of SLP to derive an adjustment factor that would be more appropriate for KDEN.

d) In my supplementary lecture slides, I recommend using a very easy to remember value of 1 hPa every 10 m (i.e. 6 hPa every 60 m) elevation gain. Based on your answers, which rule do you find is most accurate?