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.

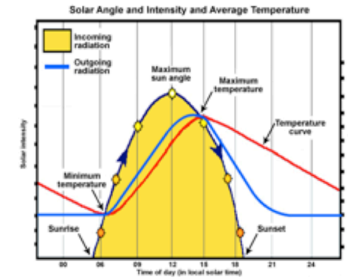
Why does the bridge get icy before the pavement on the ground when air temperatures drop below freezing? Use heat transfer concepts of Chapter 4 to explain your answer. Assume calm winds to simplify the discussion.

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 45˚F 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 radiative heat transfer.)

3) The schematic to the right was shown in the overview slides to explain the diurnal cycle of temperature in terms of radiative balance. Unfortunately, the diagram has a conceptual error (that I intentionally omitted from the narrative) 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 how to correct the diagram.
(Hint: subsection 4.5.3 of H&P.)



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

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

4) During a very cold, calm, winter night, why would you feel colder 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?

5) On a cold calm day, why would you feel warmer 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*.)

6) 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 weather for each question.

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

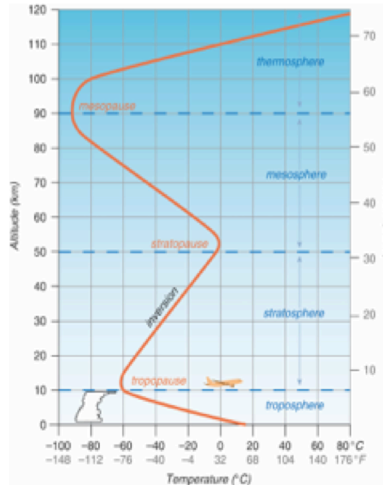
a) How would MAX temperature readings change if the thermometer was not placed in the shade?

b) How would MAX and MIN temperature readings change if the shelter was painted black instead of white?

c) How would MAX and MIN temperature readings change if the shelter was airtight?

d) How would MAX and MIN temperature readings change if the shelter was placed two inches AGL?

7) Pressure and density (with rare exceptions beyond the level of this course) always decrease 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)

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). But what does “at elevation” mean? Let’s explore how robust the “rule of thumb” adjustment of H&P is for higher elevation sites.

a) Station pressures at Tucson International Airport (KTUS), at an elevation of 806 m, have an average value of 917 hPa in July and 924 hPa in January. What would be the pressure at KTUS if adjusted to SLP using a correction of 8 hPa per 60 m? Remember to include units of pressure with your answers. (Answer: 1024.5 hPa in July; 1031.4 hPa in January.)

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 where the value is close to 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. (Answer: 6.923 hPa every 60 m.)

c) Station pressures at Denver International Airport (KDEN at an elevation of 1655 m) 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. (Answer: 6.256 hPa every 60 m.)

d) I recommend using an easy to remember adjustment of 1 hPa every 10 m (i.e. 6 hPa every 60 m) elevation gain. Based on your answers, which “rule of thumb” do you believe is most accurate?