1. (a) For an animal of your choice, compute the total radiation absorbed by the animal, $R_{abs}$, under a clear sky at night. Assume $T_a = T_g = 20 \degree C$.

(b) For that same animal, compute $R_{abs}$ under a completely overcast sky at night. Assume $T_a = T_g = 20 \degree C$.

(c) Is $R_{abs}$ higher on a clear or overcast night?

(d) Explain how this statement is not quite accurate: “Cloudy nights tend to be warmer than clear nights because clouds act like a blanket.”

(e) Explain why this statement is false: “Cloudy nights tend to be warmer than clear nights because clouds reflect radiation.”

2. 11.3 in Campbell and Norman. Note that time in (11.1) in the text is solar time. For example, 6:00 solar time is 6 hours earlier than solar noon. Be sure to consider these four components of the radiation budget: direct solar radiation absorbed by the soil; diffuse solar radiation absorbed by the soil; atmospheric radiation absorbed by the soil; and radiation emitted by the soil. Also report the net radiation.

3. 11.5 in Campbell and Norman, but use Ames, IA, coordinates: 42.0 N and 93.6 W.

4. 11.6 in Campbell and Norman, but again use Ames coordinates. Also find the beginning and end of civil twilight. Give your answers in hours and minutes in both solar time and standard time. The standard time of solar noon is computed using (11.3) in the text. For example: on January 1 ($J = 1$), solar noon occurs in Ames at

$$t_o = 12 - LC - ET = 12 - (3.6 \times \frac{1}{15}) - (-0.057) = 12.297$$

or approximately 12:18 standard time. On January 1, 6:00 solar time would be 6:18 standard time. Compare your answers with “Sun and Moon Data” link on the course website. Do they match? If not, which do you think is more accurate, and why?

5. During an experiment in 2001 I measured downwelling solar radiation (global irradiance) and downwelling thermal radiation with a pyranometer and pyrgeometer, respectively. See Figure 1. A pyranometer and pyrgeometer measure irradiance in the same way: radiation is absorbed by a black surface underneath a dome. The temperature of this black surface, monitored by a thermocouple or other type of thermometer, increases as the amount of incident radiation increases. A pyranometer and pyrgeometer differ only in the material used for the dome. See Figure 2. The dome of the pyranometer is clear and thus transmits solar wavelengths, the same wavelengths our eyes see. The dome of the pyrgeometer appears opaque to our eyes because solar wavelengths are reflected/absorbed and only thermal wavelengths are transmitted.

(a) Use data in the text file `rR8x.dat` to plot the following for days of year 188, 189, 190, 191, and 192 (July 7–11):
i. \( A = \) the downwelling thermal radiation, divided by the sum of \( A \) and \( S = \) the downwelling solar radiation;

ii. the net radiation

\[
R_n = S + A - \left( aS + \sigma T_{veg}^4 \right) \quad (2)
\]

where \( a \) is the albedo of the vegetation canopy, and \( T_{veg} \) is the temperature at the top of the vegetation canopy.

Read the comments in \texttt{rR8x.dat} to determine which variables to use. Note that we are assuming a thermal emissivity of unity for the vegetation canopy.

(b) Roughly (e.g. one-eighth, two-fifths, etc.) what fraction of the total downwelling radiation (solar plus thermal) is thermal radiation at solar noon on mostly clear days? At solar noon on mostly cloudy days? This is the contribution of the greenhouse effect.

(c) During what period of the day (approximately) is the net radiation positive?

(d) What happens to the energy associated with the positive net radiation?

(e) During what period of the day (approximately) is the net radiation negative?

(f) What is happening (physically) when the net radiation is negative?

MATLAB suggestions: use \texttt{load rR8x.dat} and use my function \texttt{timeconvert.m} on the course website. The code

\[
time = \text{timeconvert}(\text{rR8x(:,3)}, \text{rR8x(:,4)}, \text{zeros(size(rR8x(:,3))));}
\]

will generate a variable \( \text{time} \) that can be easily used in the \texttt{plot} command to plot any of the variables in \texttt{rR8x.dat}.

If interested (you don’t have to do this, it’s only for fun), plot other components of \( R_n \) and see how they each vary over time.

6. Read the abstract, introduction, and conclusion of “Does Daylight Saving Time Save Energy? Evidence from a Natural Experiment in Indiana” at \texttt{doi:10.1162/REST_a_00131}.

(a) Who appears to be the first to propose the idea of adjusting people’s schedules in response to the variation in the time of sunrise and sunset throughout the year, and what was the argument for doing so?

(b) Give a short summary of the history of daylight saving time (DST) in the United States.

(c) What special circumstances occurred in Indiana that allowed the authors to conduct this analysis?

(d) What did the authors find?

(e) Why may these findings be a recent phenomenon, i.e. perhaps 40 years ago a different conclusion would have been reached?

(f) Besides energy consumption, what are some other possible benefits of DST?

(g) What is your opinion: should we observe DST?
Figure 1: Micro-meteorological tower in Southeastern Michigan, July, 2001. A pyranometer and pyrgeometer are situated on the end of the long arms.

Figure 2: A pyranometer (left) and pyrgeometer (right).