Assignment 5: Insolation and orbital variations

Instructions:

The questions below require you to calculate daily average insolation over the course of the calendar year at different locations, and with different orbital parameters. You will use the function `orbital.daily_insolation( )`, following examples posted on the class web page.

Save your code into a single Python file, called e.g. `Rose_assignment5.py` (replace "Rose" with your name…). Save this file in the same directory as `orbital.py`. The first two lines of your file should be

```
from pylab import *
import orbital
```

followed by your code. Edit your code so that it contains ONLY what is needed to compute insolation and draw the graphs. Try to include comments on what the code is doing (see below) so I can understand your thought process.

You can easily run your code from start to finish by clicking the "run" button (green arrow) on the Canopy toolbar. Every time you edit or add something new to your code, run it again to make sure it does what you want. It may be necessary to include this command:

```
show()
```

at the end of your plotting code for each figure.

Important: In the same code file, **include your answers to the questions in words, using comments.** *In Python, a comment always starts with the symbol #. Any text after # on a line is ignored by the Python interpreter.*

Your final code file should contain everything necessary to generate the two graphs automatically when executed from a clean start.
To verify this, select "Restart kernel" from the Canopy Run menu *(same as quitting and re-starting Canopy, will erase everything in memory)*, make sure your current directory is set properly, and type (using the appropriate name):

```
import Rose_assignment5
```

Did your two graphs appear on the screen looking the way you want them, and with no errors? Good. If not, continue to edit and re-run your code until you are satisfied. Then save your two graphs as image files (.png, .eps, .pdf, .jpg, .tif, or anything else I can read).

Submit by email: one well-commented code file including your answers, and two image files containing your graphs.

There is an optional bonus question for those who are interested and want to earn some extra credit. It will require generating a third figure.

Questions

1) Using the function `orbital.daily_insolation( )`, calculate the incoming solar radiation (*insolation*) at three different latitudes: the equator, 45ºN, and the North Pole. Use present-day orbital parameters.
   a) Make a graph that shows all three insolation curves on the same plot. The x axis of your graph should be days of the calendar year (beginning January 1), and the y axis should be insolation in W m^{-2}. Include a legend showing which curve corresponds to which latitude.
   b) Comment on the very different shapes of these three curves.

2) Make the same graph using the orbital parameters of 10,000 years ago (just after the end of the last ice age). Compare with your graph from Question 1 to answer these questions:
   a) Was the insolation at northern high latitudes at summer solstice weaker or stronger 10,000 years ago compared to present conditions?
   b) Was the summer season longer or shorter at high northern latitudes? To see this, look at the length of time between polar sunrise and polar sunset.
   c) What other differences do you notice?

BONUS (for fun and extra credit):

Make the same graph for a planet with zero eccentricity and 90º obliquity. Speculate on what the seasonal cycle of temperature might look like at different locations on this planet.

(90º obliquity means the planet's rotation axis is parallel with the earth-sun plane, as if the planet were lying on its side. In our solar system, the planet Uranus has an obliquity close to 90º, as do many of the newly discovered extra-solar planets).