1 Basic solar pattern problems

Answer the following for a planet in a circular orbit having an obliquity of 20°. Give answers at eight times of year: both solstices, both equinoxes, and the times midway between solstices and equinox.

- (a) What is the latitude of the Sun?

- (b) Assuming the planet has a 24 hour rotation period, what is the length of the day at latitude 45°N?
• (c) A tall, skinny tower with height 300m is built at latitude 45°N. What is the length of the shadow cast by this tower? Give your answers at local solar noon, and at 3 hours past local noon (based on a 24 hour day). *Hint: Think about the zenith angle*

2 **Effect of obliquity on temperature**

Compute the summer and winter solstice temperature at latitude 60°N and at the Equator, for a planet with 20° obliquity, assuming a solar constant of 1370 W/m². Compute the annual mean temperatures at 60°N and the Equator. Compute how much these temperatures change if the obliquity is increased to 23°. Assume the orbit to be circular.

In converting fluxes to temperature, you may assume \( OLR(T) = 172 + 2.3 \cdot (T - 250) \), which corresponds to an Earthlike atmosphere with 300 ppm CO₂ in it, and water vapor held at 50% of saturation.

3 **Climate on a high-obliquity waterworld**

On a water world with a deep mixed layer ocean, the temperature is very nearly the annual mean all year around. Compute the annual mean temperature vs. latitude for a planet having 50° obliquity, in a circular orbit, and with \( L_\odot = 1370 W/m^2 \). Assume the albedo to be .2.

In converting fluxes to temperature, you may assume \( OLR(T) = 172 + 2.3 \cdot (T - 250) \).

4 **Basic orbit shape**

Sketch the shape of an orbit having eccentricity .2, showing the position of the Sun, the semi-major axis, the perihelion, the aphelion and the ratio of the semi-major to semi-minor axes.

5 **Distance vs. tilt seasons**

Currently Mars has an eccentricity of about .1 and an obliquity of about 25°. The Solar constant, evaluated at a distance equal to the semi-major axis is
589 W/m². Currently, the precession angle is such that the planet is nearly at aphelion during the Southern Hemisphere Winter Solstice.

Find the solar flux incident on the North Pole at Northern Summer Solstice. Compare this to the solar flux incident on the South Pole at Southern Summer Solstice. Compare the Winter Solstice fluxes at 60°N and 60°S. Which hemisphere has “hot” summers and cold winters? Which hemisphere has mild summers and mild winters?

6 Milankovic cycles on Earth

Use the script FluxExplorer to generate maps of the latitude-time distribution of flux factor for Earth’s actual orbit at present, 5000 years in the past and 10000 years in the past. At the two past times, where and in what seasons would you expect the climate to be warmer than today?

What was the Earth’s eccentricity 100,000 years ago? How would you expect this to affect the pattern of solar radiation, if the obliquity and precessional angle were the same as today? Use FluxExplorer to make a map illustrating this effect. (100,000 years ago was approximately the time of the last major interglacial period).