Classroom Demonstration Guidelines
(Basic Coordinates & Seasons)

The following sequence of directions are steps an instructor might choose to follow in demonstrating the Seasons & Ecliptic Simulator of the Basic Coordinates & Seasons Module in a classroom situation. We provide these suggestions with appropriate questions (shown in bold italics) to pose to the class as an aid in promoting interactivity. We encourage instructors to adapt these suggestions to their particular educational goals and the needs of their class.

Animation Demonstration Directions	Interactive Questions
Begin using the applet in its default configuration. The left panel will be in **orbit view**. Drag the perspective of the Earth's orbit so that you are looking down on the plane of the solar system.	***What is the shape of the Earth's orbit around the sun?*** (the orbit is programmed as circular in this simulator, but it is really elliptical, e = 0.017) ***Can varying distance from the sun be responsible for the Earth's seasons****?* (No)
Use the yearly slider to change the date to June 21 and drag the earth to the 9 o'clock position (far left). Now drag the perspective of the Earth's orbit so that we are looking along the plane. (We want an orientation where the summer solstice is on the far left so the winter solstice will be on the far right.)	***What is this day of the year called?*** Summer solstice) ***What season is it in the northern hemisphere?*** (summer) ***What season is it in the southern hemisphere?*** (winter) ***If varying distance were responsible for seasons, could you get different seasons in the two hemispheres?*** (No)
Point out to students that the yellow arrow represents the direct rays of the sun.	***Where on the Earth are the direct rays of the sun hitting?*** (Tropic of Cancer)
Change the upper right panel to **view from sun** to illustrate this and point out the sub-solar disk. Then change the upper right panel to **view from side** and drag the observer to the Tropic of Cancer.	***Where does this observer see the sun at noon?*** (directly overhead)
Make sure that the lower right panel is set to **sunlight angle** and point out that the sun's altitude is 90° (at the zenith).	
Click **start animation** and run the animation to December 21.	***Where is it summer now on the Earth?*** (in the southern hemisphere) ***Where are the direct rays of the sun hitting on the winter solstice?*** (on the Tropic of Capricorn).

	What is the significance of the tropics? (in between the Tropics the sun can be at your zenith)
Drag the observer in the upper right panel up to the Arctic Circle. Point out the sun's altitude in the lower rightt is 0°-- on the horizon.	***Relative to where the direct rays are hitting the Earth, where are the least direct rays hitting?*** (90° away) ***If one experiences direct rays when the sun is at their zenith, where is the sun located when one experiences the least direct rays?***(on the horizon) ***Where on the Earth would the least direct rays be hitting on the Winter Solstice?*** (the Arctic Circle)
Drag the observer up to an even greater altitude like 80° N.	***What does the sun look like to this observer?*** (the observer doesn't see the sun on this day.) Remind students that in 24 hours the observer makes a circle around the pole and thus remains in the shaded area.
Now drag the observer down to latitude 80° S.	
Now drag the observer down to the South Pole and click Start Animation.	***What does the sun look like to this observer on the Winter Solstice?*** (the sun doesn't set during the day)
Click **start animation**.	Let's watch the sunlight that this observer receives throughout the year. (30 seconds of observation) ***So what is this observer's year like?*** (6 months of sunlight and 6 months of darkness) ***So is sunlight most appropriately described as a daily or seasonal phenomena? (Or does it depend where you are on the Earth?)*** (seasonal north of the arctic circle and south of the Antarctic circle, daily in between.)
Stop the animation and drag the observer up to a latitude of about 50° N. Change the lower right panel to **sunbeam spread** and then click **start animation**.	This spot illustrates a beam or "cylinder" of sunlight and the larger the area that it is spread over the smaller its intensity. Let's watch the change in intensity throughout the year. ***So what directly causes seasons?*** (The variation in sunlight intensity throughout the year.) Another factor is the percentage of time that the sun is above the horizon. Emphasize

Drag the Earth back and forth between the summer solstice and winter solstice positions in the left panel and point out to students how the sunlight intensity varies between the northern and southern hemisphere.	to students that this important factor cannot be seen in this simulator -- but is covered extensively in our Motion of the Sun simulator. ***So what is the underlying cause of this variation in the intensity of sunlight?*** (The 23.5° tilt of the Earth's axis of rotation – the obliquity).
Change to the **celestial sphere** view in the left panel. The viewer's perspective will now be seeing the celestial equator edge on and the date should be Dec. 21.	***On the winter solstice does the observer see the sun north or south of the celestial equator?*** (south) ***What about on the summer solstice?*** (north of the celestial equator) ***Why does the sun have this strange (apparent) path on the celestial sphere?*** (Because of the 23.5° tilt of the Earth's axis of rotation). ***If the tilt of the earth were larger, would the seasons change in any way?*** (Yes, they would be more intense).