Classroom Demonstration Guidelines
(Motions of the Sun)

The following sequence of directions are steps an instructor might choose to follow in demonstrating the Paths of the Sun simulator 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. Discuss with students that this simulation allows you to look at the path of the sun for any latitude on the Earth on any day of the year.	
Click **start animation** (in continuous mode, loop day off) so that they can see this capability. Stop the simulator a few days later near noon. Check **show months labels** to help illustrate the ecliptic.	***What is the significance of the white circle shown on the celestial sphere?*** (this is the ecliptic the apparent yearly path of the sun on the celestial sphere)
Change the date by dragging the yearly slider and emphasize how the two circles intersect on today's date on the ecliptic.	***What is the significance of the yellow circle shown on the celestial sphere?*** (this is the daily path of the sun). Think of the daily path as the apparent motion of this point on the ecliptic as the Earth rotates. Mixing up the daily and yearly motion is a common problem that students have with this material.
Change the date to the vernal equinox. You should still be at a latitude of 41°N.	***What is the rising azimuth of the sun on this date****?* (90°) ***Where will the sun rise in upcoming days?*** (towards the north at lower azimuths) ***What is the setting azimuth of the sun on this date****?* (270°) ***Where will the sun set in upcoming days?*** (towards the north at larger azimuths)
Change the animation option to **step by day** and click **start animation** to watch this demonstrated. Point out that when the sun rises north of east it sets north of west – and when the sun rises south of east it sets south of west.	***What is the meridinal altitude of the sun on the vernal equinox from 41°N.*** (49°) ***What is the range of meridinal altitudes throughout the year.*** (25.5° to 72.5°, 49°±23.5°)

To illustrate this lets compare the amount of time the sun is above the horizon on the summer and winter solstice. Change the date back to June 21 and make sure the **time of day** radio button related to dragging the sun's position is selected. Drag the sun over to the eastern horizon. Now drag the sun over the western horizon. Change the date to December 21 and repeat.	Besides the meridinal altitude of the sun, another very important factor governing seasons is the length of time that the sun is above the horizon in a day. **What time does the sun rise on the summer solstice?** (about 4:30) **What time does the sun rise on the summer solstice?** (about 19:30) **So how long is the sun above the horizon on the summer solstice for a latitude of 41º N?** (about 15 hours) **What time does the sun rise on the winter solstice?** (about 7:25) **What time does the sun rise on the winter solstice?** (about 16:35) **So how long is the sun above the horizon on the winter solstice for a latitude of 41º N?** (about 9 hours) So we see that there are two factors giving us seasons. On the summer solstice the sun goes up to a meridinal altitude of 72.5º and is above the horizon for 15 hours. On the summer solstice the sun goes up to a meridinal altitude of 25.5 and is above the horizon for about 9 hours.
Change location to the equator and put the date back to the vernal equinox. Change the yearly slider to June 21, set the animation option to **continuous** with **loop day** checked, and click **start animation** to demonstrate this. Change the yearly slider to Dec 21 to	***What is the azimuth of the rising sun?*** (again 90°) ***What is the meridinal altitude?*** ***(***90°, the sun passes through the zenith) ***What would the path of the sun look like on the summer solstice?*** (the sun rises slightly north of east, travels up to a meridinal altitude of 66.5, and sets slightly north of west) ***What would the path of the sun look like on the winter solstice?*** (just like the summer solstice but on the other side of the celestial

demonstrate this. Change the animation mode to step by day and click **start animation** to demonstrate the paths throughout the entire year.	equator)
You may wish to measure the time is above the horizon for various times of year at the equator. You will find very little variation.	Note how the noon-time sun is very nearly overhead throughout the whole year leading to very warm weather all year long. ***What is this region called where the sun can be directly overhead?*** (the tropics – between the Tropic of Cancer and the Tropic of Capricorn)
Change the location to the north pole and set the date to December 21 to demonstrate this.	***What would the path of the sun look like on the winter solstice from the North Pole?*** (it wouldn't rise – a ring 23.5° below the horizon)
Change the date to June 21 to demonstrate this. Change the animation mode to **step by day** and click **start animation** to demonstrate the paths throughout the entire year.	***What about the summer solstice path*** (a ring 23.5° above the horizon)
Change the latitude to the Arctic Circle and click **start animation** in the **step by day** mode.	***We have seen how the sun would rise and set from a latitude of 41° and how the effects of the midnight sun occur at the north pole. Where would you expect the borderline between these two behaviors to occur***? (on the Arctic Circle) Point out how the sun just barely rises and sets each day. On the summer solstice, the sun skims the north point on the horizon – at any greater latitude the sun would stay above the horizon all day. On the winter solstice, the sun skims the north point on the horizon – at any greater altitude the sun would not rise on that day.