Simulated Four-season Sunlight Device

Purpose

Use the simulated four-season sunlight device to simulate diurnal cycle and seasonal variation in different latitudes.

1. Understand that the change of day and night and seasonal variation are results of the Earth rotation and resolution.
2. Length changes of a shadow stick in one day.
3. Measure elevations and azimuths of the Sun.
4. Observe length changes of day and night in different seasons.
5. Understand seasonal variation in different latitudes.
6. Different incident angles of the Sun ray results in the coldness in high latitudes.

Theory

It is the Sun that influences cold in winder and hot in summer. Hence, through the observation of the Sun in the sky, we can determine the season. As early as China Zhou dynasty, ancient people used shadow sticks to determine the season. This is also one of the methods that people use to determine the location of the Sun in the sky (**figure 1**).

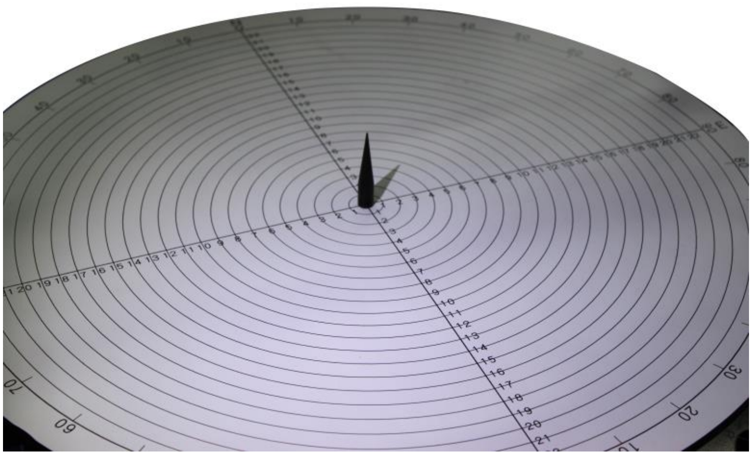

Figure 1 Shadow stick experiment

With a shadow stick, we can measure the elevation of the Sun in the sky. At midday, the shadow is at its longest length so the Sun is at its lowest in the sky over the horizon. If the shadow is at its shortest length, the Sun is close to the zenith. However, Taiwan locates in the northern hemisphere so the shadow we measured is close to the north. This indicates the Sun is close to the south. According to the changing lengths of the shadow at every midday, we know the Sun moves everyday. Thus, in spring, the length of the shadow gets shorter because the Sun is inclined to the north everyday and reaches its most northerly declination on the day of summer solstice. Winter solstice is the day that the Sun reaches its most southerly declination. Summer and winter solstice occur once every year.

After a long period of observation, in winter solstice, the Sun is at the 23.5° south of celestial equator. In winter solstice, the sun rays strikes latitude 23.5° south; in spring equinox and autumnal equinox, the ray of the sun strikes celestial equator which is 0° latitude. In summer solstice, the ray of the Sun is at the 23.5° north of celestial equator. **Figure 2** is the figure of seasonal variations.

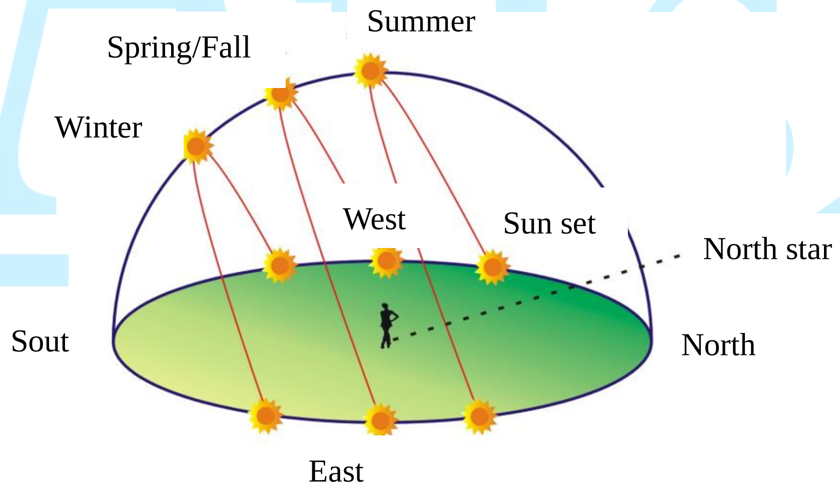

Figure 2 Seasonal variations

It takes one year for the Earth to finish its revolution around the Sun. The axial tilt of Earth is 23.5°. Due to the tilt angle, the incident angle of sun rays changes in the Earth revolution. The different incident angles are reasons of changing temperatures and different absorbed heat of an area. This is also what we called seasonal variations.

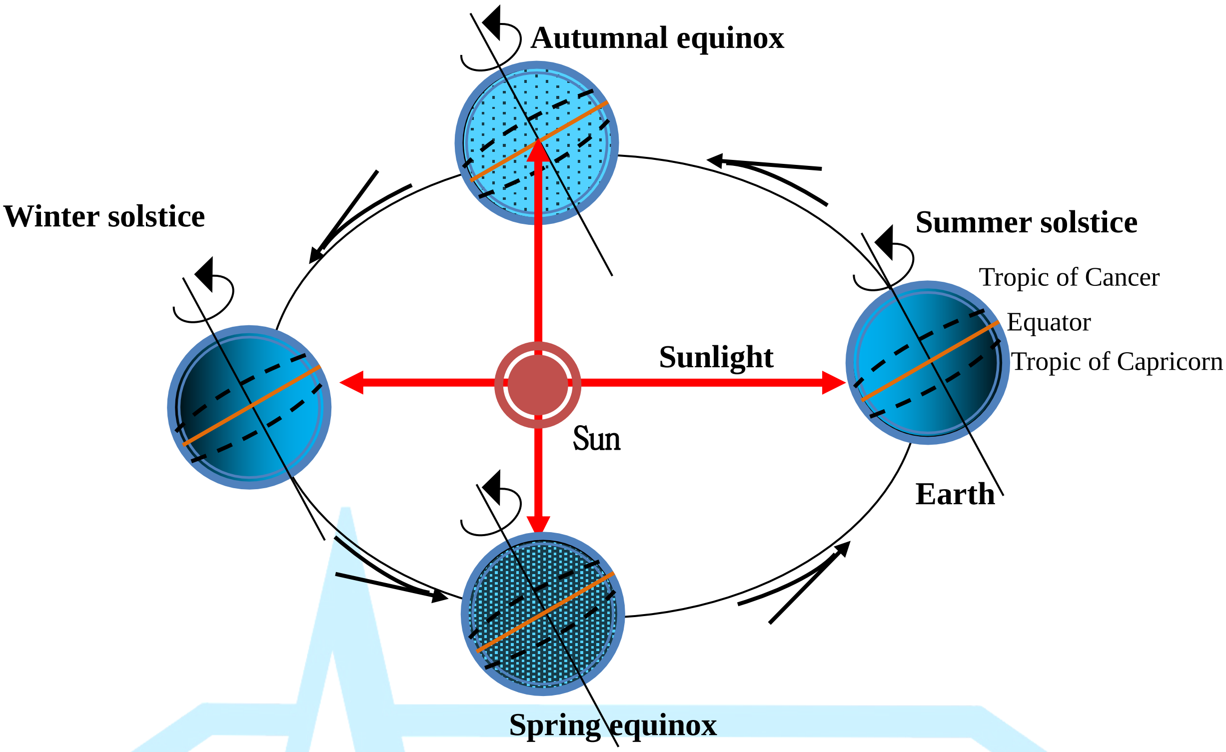

Figure 3 Orbit of Earth around the Sun

Take the northern hemisphere as an example. According to **figure 3,**

1. Spring equinox (March 21/ 22): The Sun shines directly on the Earth’s equator and will moves north.
2. Summer solstice (June 21/ 22): The Sun is directly over the tropic of cancer and will move south.
3. Autumnal equinox (September 21/ 22): The Sun shines directly on the Earth’s equator and will move south.
4. Winter equinox (December 21 / 22): The Sun is directly over the tropic of Capricorn and will move north.

The circulation goes around year after year.

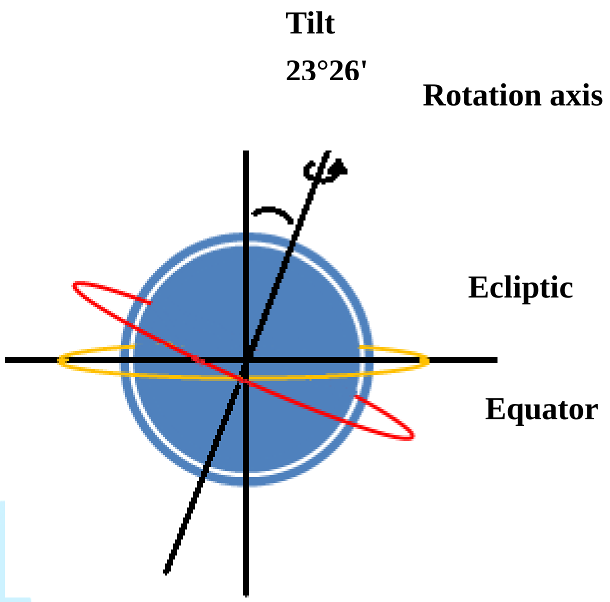

Figure 4

Ecliptic

Assume the Earth is still and the Sun orbits around the Earth. The orbit plane of the Sun around the Earth is the plane of ecliptic. Equator is the plane that is perpendicular to the Earth's rotation axis. The angle of ecliptic and the equator is 23°26' (**figure 4**).

Day and night

The Earth rotates on its axis every 24 hours so areas facing the Sun have daylight while areas facing away from the sun have nighttime.

Length of day and night

In the Earth's rotation and revolution, the Sun shines directly on the equator in spring equinox and autumnal equinox. The length of day and the night is nearly equal in high and low latitude areas. (**figure 3**). ‘

During winter solstice to summer solstice, the Sun is moving slowing to north so areas in southern hemisphere receive less amount of sunlight. While the amount of sunlight in northern hemisphere increases, the length of day also gets longer. Areas inside the circle of latitude are smaller so high latitude areas have even longer day length. Areas inside polar circle even have polar day.

During summer solstice to winter solstice, the Sun is moving slowly to the south so the areas in the northern hemisphere receive less sunlight and the length of day gets shorter. Areas inside the circle of latitude are smaller so they receive even less sunlight. Areas inside the polar circle even have polar night.

Seasonal variations

The angle between the Earth's rotation axis and the plane of the ecliptic is 23.5° so in the period of Earth revolution, the different positions of the Sun causes distinct seasonal variations (**figure 5**).

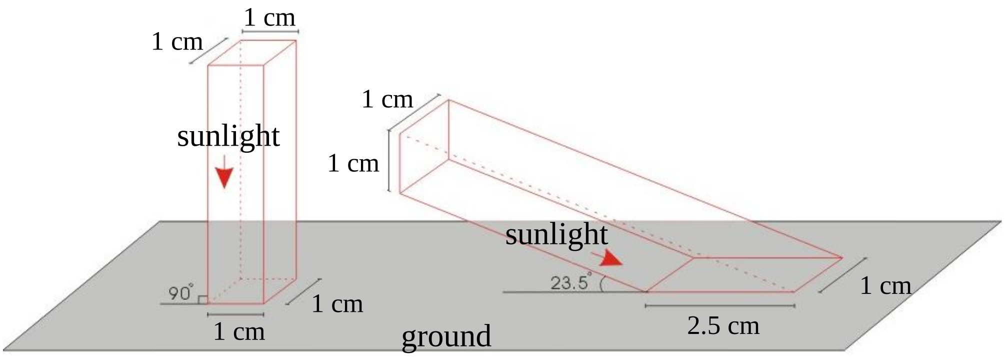

Figure 5 Incident angles of the Sunlight affects temperatures and areas that receive the Sun.

Incidence angles of sunlight (direct and oblique)

The sunlight contains the same amount of energy. Areas that receive oblique sunlight are bigger than areas that receive direct sunlight so the energy per unit area receives is different (**figure 5**). The incident angle of sunlight in different latitudes varies in different seasons (**figure 4**) so the length of daylight and temperatures also vary. Hence, areas in different latitudes have different length of daylight.

Atis Scientific Instruments Co.,Ltd
Address：1F., No.18, Nanming St., South Dist.,
Tainan City 702, Taiwan (R.O.C.)
E-mail:atis@atissi.com.tw
Tel: (886) -6-2925201
Fax: (886)-6- 2611476
Mobile:+886-9-8006-1128
Website: www.atis.com.tw