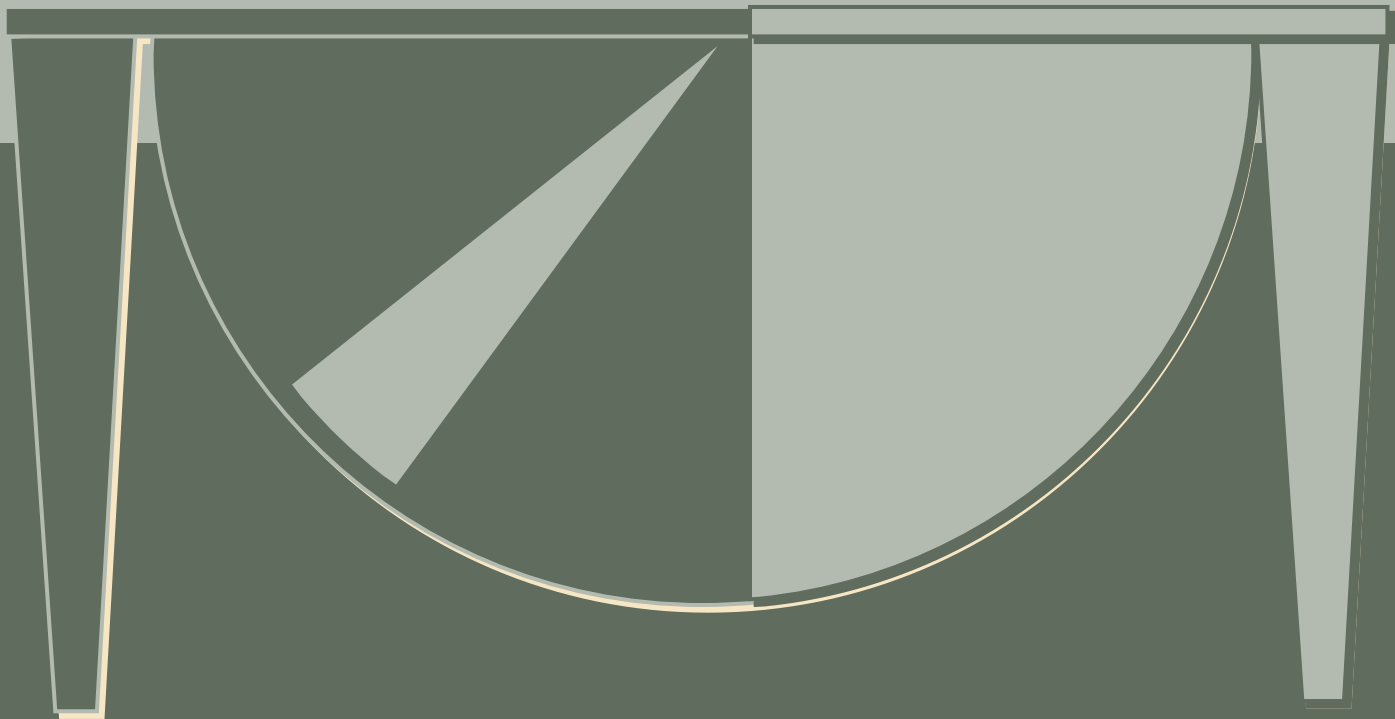


<For Student>

# Exploring the Principles of Angbuilgu



# Exploring the Principles of Angbuilgu

Integrating Curriculum Unit – Exploration of the Universe : Exploring the Principles of the Sundial

## Learning Objectives

1. I can explain the functions and principles of each structure in Angbuilgu.
2. I can create an Angbuilgu model that corresponds to the latitude and measure time.
3. I understand and can discuss the concepts of the celestial sphere, time, and calendar.

## I. Overview

Since ancient times, people have been creating and using various timekeeping devices such as water clocks and hourglasses to measure time. However, these clocks all have the disadvantage of not maintaining a consistent time interval. To the people of the past, the most regular motion they observed was that of celestial bodies, particularly the sun, which rises and sets every day and can be seen for extended periods. Therefore, they used the motion of celestial bodies, especially the sun, to determine the time. Additionally, to make it possible for the common people who had difficulty confirming the time through celestial observations, a hemisphere-shaped sundial called "Angbuilgu" was created.

Angbuilgu (仰釜日晷, 앙부일구) was created in the 16th year of King Sejong's reign (1434) by individuals such as Jang Yeong-sil, Yi Cheon, and Kim Jo. The clock face is concave like a cauldron, and the name "Angbuilgu" was given because this cauldron seems to reach up to the sky. Let's take a closer look at the appearance of Angbuilgu on the **Detailed Examination**. Also, let's explore the principles of Angbuilgu on the next page.

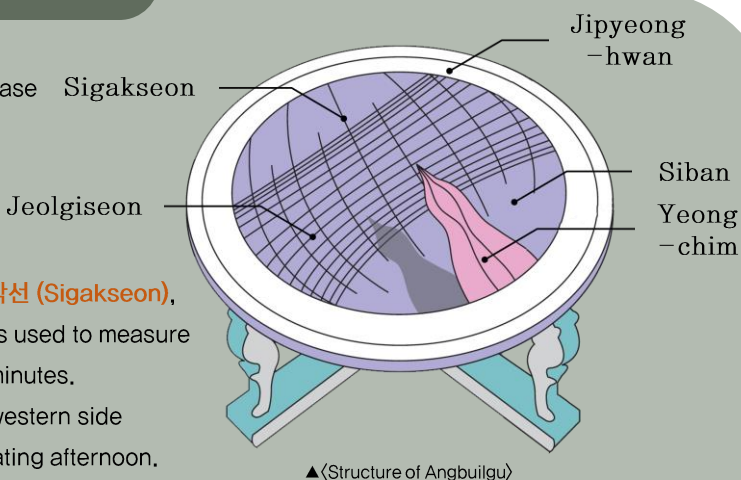


### Detailed Examination

The round vessel that makes up Angbuilgu is called the "**시반(Siban)**," and it serves as the base of the clock. The Siban has lines representing the time and the seasonal divisions, playing a crucial role in timekeeping. By observing the position of the shadow cast on the siban, one can determine both the time and date. **시각선 (Sigakseon)**, which translates to "time line," are vertical lines used to measure time. The intervals between the 시각선 are 15 minutes.

The central 시각선 represents noon, with the western side indicating morning and the eastern side indicating afternoon.

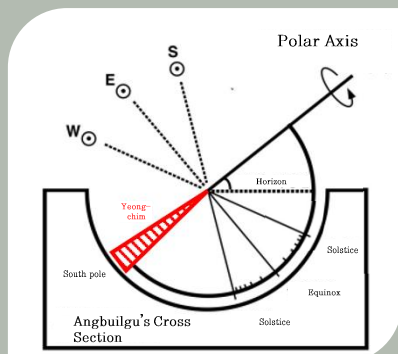
**절기선 (Jeolgiseon)** are horizontal lines representing the seasonal divisions and dates. The topmost 절기선 corresponds to the summer solstice (하지), while the bottommost 절기선 corresponds to the winter solstice (동지). The intervals between the 절기선 are not uniform due to the unequal positions of the ecliptic and the equator. **영침 (Yeongchim)** plays a role similar to that of a clock's hour hand. By observing the shadow of the 영침 and its intersection with the 시각선 and 절기선, one can determine the time and date. **지평환 (Jipyehwan)** is a ring-shaped vessel that contains information about time and date. This system allows people to tell time and date accurately using the sun's shadow and the unique features of Angbuilgu.



▲〈Structure of Angbuilgu〉



## Detailed Examination



Indeed, all celestial bodies appear to move around the Earth's axis, parallel to the Earth's equator, completing one full rotation in a day. To project this motion onto the Angbuilgu's Siban, **the Yeongchim must always point towards the Northern Celestial Pole**. However, as you mentioned, the angle between the Earth's equator and the horizon changes with **latitude**. Consequently, the position of the Northern Celestial Pole also changes with latitude. Because of this, when the latitude changes, the positions of not only the Angbuilgu's Yeongchim but also the Jeolgiseon need to be adjusted.

## II. Supplies

- 3D Printer
- Compass
- Level

## III. Process

### (1) Printing Angbuilgu

Enter the desired location on the website and download the 3D model of Angbuilgu. Use a 3D printer to create an Angbuilgu with dimensions of approximately 18 cm.

### (2) Installing Angbuilgu

Place Angbuilgu on a flat surface with no inclination. If the ground is not level, adjust the horizontal alignment of Angbuilgu using a desk or tripod if necessary. Ensure that there are no buildings obstructing the sunlight in the vicinity and conduct the experiment in a spacious and open area.

### (3) Aligning with True North

Use a compass to find the Northern Celestial Pole. Align Angbuilgu in the direction of true north that correcting the azimuth based on the long line drawn on the horizon ring (not the line marked with 'N' on Angbuilgu) to match the north indicated by the compass.

### (4) Recording

Confirm the position indicated by the end of the shadow cast by the yeongchim and use it to measure the time and date. Record the measured data (time, date) in your experiment log. Also, record the data obtained from the satellite clock (smartphone clock) for comparison (time, date).



## CHECK!

- Ensure that the Angbuilgu is accurately installed by using a level to achieve proper horizontal alignment. (o, x)
- Install the Angbuilgu gnomon in a way that it points towards the celestial North Pole. (o, x)
- Securely fix the Angbuilgu during the measurements to prevent any changes in its designated position. (o, x)

※Not following the above precautions may result in significant errors in the readings.

## IV. Result and Discussion

(1)Let's record the measurement values.

Latitude	
Longitude	
Declination	

Date	
Time	

Time measured by Angbuilgu	
Date measured by Angbuilgu	

(2) Is there a difference between the values measured through Angbuilgu and those confirmed using a smartphone clock? If differences exist, explain the reasons using the concept of Equation of time.

(3) Let's compare the time determined using Angbuilgu, adjusted for Equation of time based on the almanac published by the Korea Astronomy and Space Science Institute, with the time confirmed using a smartphone clock.

(4) Is the time difference still evident as observed in (3)? If there is a difference, let's consider the reasons, brainstorm potential methods of adjustment, and discuss them.

(5) What are the advantages of changing the support base of Angbuilgu into a tripod shape, and how can this be related to mathematical principles?