

The yearly motion of the sky

Astronomy 101
Syracuse University, Fall 2022
Walter Freeman

September 8, 2022

The Sun and the stars: the zodiac

This is the excellent foppery of the world, that, when we are sick in fortune, often the surfeit of our own behaviour, we make guilty of our disasters the sun, the moon, and the stars; as if we were villains on necessity; fools by heavenly compulsion... An admirable evasion of whore-master man, to lay his goatish disposition to the charge of a star!

—William Shakespeare, *King Lear*

For in that event [the stars dictated our fates], every single individual would lack the power to do anything he set his mind to, since something else draws him on – against his will – to be this and not to be that...

—Maimonides (c. 1135-1204),
Spanish / North African Sephardic scholar

I'm catching up answering my email; I hope to be caught up Friday.

- What should you do if you must miss your lab?
 - Look at the lab schedule and find another section/sections you might want to attend
 - Email or both your TA and the TA the other section
 - Tell them what is going on, and ask if there are any empty seats in their section
 - If both TA's approve the swap, attend the other section
 - We will take care of entering grades; it is your responsibility to get your work back from the other TA
- If it's for a *compelling reason* (illness, emergency, academic/professional conflict, family commitment), you may do this as you need.
- You may do this for any other reason **once** per semester.

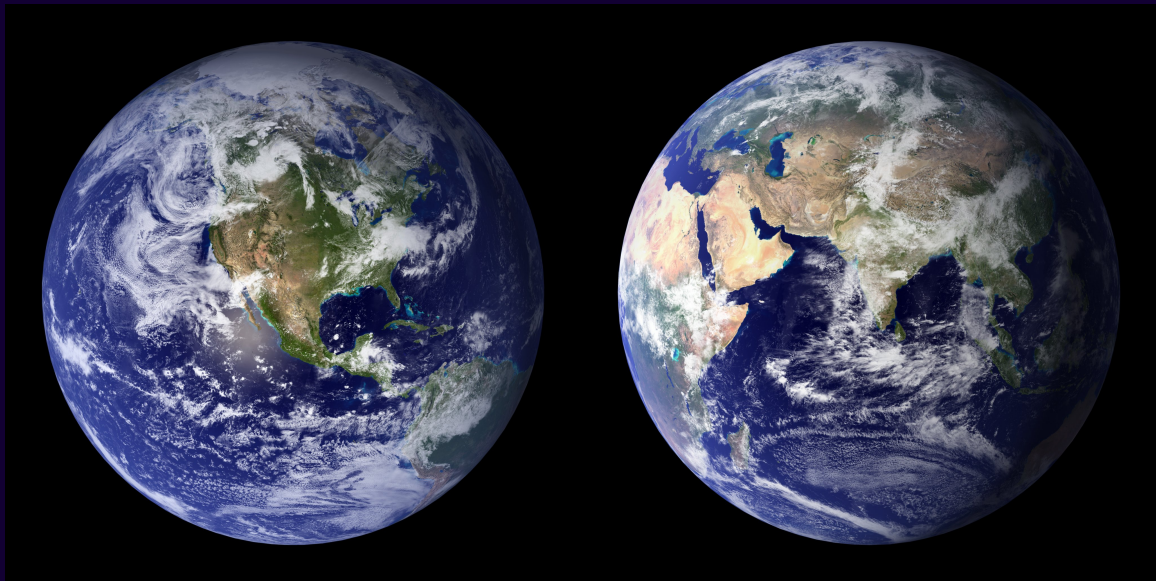
- What should you do if you must miss your lab?
 - Look at the lab schedule and find another section/sections you might want to attend
 - Email or both your TA and the TA the other section
 - Tell them what is going on, and ask if there are any empty seats in their section
 - If both TA's approve the swap, attend the other section
 - We will take care of entering grades; it is your responsibility to get your work back from the other TA
 - If it's for a *compelling reason* (illness, emergency, academic/professional conflict, family commitment), you may do this as you need.
 - You may do this for any other reason **once** per semester.
- You do *not* need to tell me unless I need to do something.

Announcements: Homework quiz 1

Your first quiz is next Tuesday (not today), during the last portion of class. It will have three questions, as described on the homework.

If you have a CDR accommodation for extra time or a lower-distraction environment, we can provide that for you in the physics building.

You may go to CDR's facility too if you choose.



What kind of world is this? What *can't* you see?

Questions about the exercises or homework? Want to study with me?
Come chat!

This is the absolute very best thing you can do to study for our class.

Come by the Clinic, Physics Building 112, and ask questions, or ask on Discord.

I have office hours Wednesday 2-4 or Monday 10-12; come see me in room 215!

Today: consequences of the Earth's **revolution**:

- How is the Sun different from the other stars?
- What's this zodiac business?
- What does it mean for the Sun to be “in Aries”?

Today: consequences of the Earth's **revolution**:

- How is the Sun different from the other stars?
- What's this zodiac business?
- What does it mean for the Sun to be “in Aries”?
- We will see how this is only complicated because of **how we keep time**

Which is true about the Sun?

A: The celestial sphere model predicts its motion exactly

B: The celestial sphere model predicts its daily motion, but isn't accurate for longer times

C: The celestial sphere model is completely wrong for the Sun

Why is the celestial sphere model a bit wrong for the Sun?

A: The Sun is close enough that the Earth's movement matters, unlike for other stars

B: The Sun lies on a different celestial sphere than the stars, which turns at a different rate

C: The Sun is different from the other stars and we can't use the same logic to understand how it works

D: The Sun is close enough that we notice its movement, unlike the other stars

Why is the celestial sphere model a bit wrong for the Sun?

A: The Sun is close enough that the Earth's movement matters, unlike for other stars

→ This is the modern perspective: the Earth's movement carries it to the other side of the Sun during a year.

B: The Sun lies on a different celestial sphere than the stars, which turns at a different rate

→ This was the ancient perspective: they imagined that the Sun's rotated just a little bit slower.

C: The Sun is different from the other stars and we can't use the same logic to understand how it works

→ Since the Sun is like all the other stars but just closer, we should be able to understand it in the same way.

D: The Sun is close enough that we notice its movement, unlike the other stars

→ This isn't correct – the Sun doesn't move much, just like the other stars don't move much, over one year.

A demonstration

Let's use *Stellarium* to revisit the same time every night – say, midnight.

A demonstration

Let's use *Stellarium* to revisit the same time every night – say, midnight.

... What's wrong?

A demonstration

Let's use *Stellarium* to revisit the same time every night – say, midnight.

... What's wrong?

... isn't the celestial sphere supposed to rotate once per day?

... Why are the stars moving?

... What's wrong?

A demonstration

Now let's look at the sky during the *daytime*, pretending the atmosphere is gone.

A demonstration

Now let's look at the sky during the *daytime*, pretending the atmosphere is gone.

Which moves more, the sun or the stars?

A demonstration

Now let's look at the sky during the *daytime*, pretending the atmosphere is gone.

Which moves more, the sun or the stars?

- The Sun just moves up and down a little bit, and the stars spin!
- ... why is this?

Understanding this

We need two pieces to understand this fully.

- First, we need to understand what the sky looks like as Earth moves around the Sun. This is your exercise.
- Then, we need to return to this question of “what happens in a day?”.

Let's try to understand this on paper.

Work through the exercise for today. Your next homework is on the back.

We will talk about astrology and timekeeping after this.

The Zodiac and the astrological calendar

Imagine that you are the ruler of an ancient civilization – with a keen mind, but no modern technology.

The Zodiac and the astrological calendar

Imagine that you are the ruler of an ancient civilization – with a keen mind, but no modern technology.

How do you know when it is September?

The Zodiac and the astrological calendar

Imagine that you are the ruler of an ancient civilization – with a keen mind, but no modern technology.

How do you know when it is September?

How do you know when it is December?

The Zodiac and the astrological calendar

Imagine that you are the ruler of an ancient civilization – with a keen mind, but no modern technology.

How do you know when it is September?

How do you know when it is December?

How do you know when a new year starts?

The Zodiac and the astrological calendar

Imagine that you are the ruler of an ancient civilization – with a keen mind, but no modern technology.

How do you know when it is September?

How do you know when it is December?

How do you know when a new year starts?

You know that you have to plant your crops in mid-April. How do you know when that is?

The Zodiac and the astrological calendar

Imagine that you are the ruler of an ancient civilization – with a keen mind, but no modern technology.

How do you know when it is September?

How do you know when it is December?

How do you know when a new year starts?

You know that you have to plant your crops in mid-April. How do you know when that is?

Your gods want you to celebrate them on the same day every year. (The gods will be very angry if you don't get this right!) How do you make sure you keep your gods happy?

The motion of the Sun through the constellations of the Zodiac isn't just a means of divination/fortune-telling.

The Zodiac and the astrological calendar

The motion of the Sun through the constellations of the Zodiac isn't just a means of divination/fortune-telling.

It's a means of *telling time* during the year.

The Zodiac and the astrological calendar

The motion of the Sun through the constellations of the Zodiac isn't just a means of divination/fortune-telling.

It's a means of *telling time* during the year.

How does it compare to *other ways* of telling time of year?

What is a day?

How should we define a *day*?

- A: $1/365$ of a year
- B: The amount of time from midnight to midnight, or noon to noon
- C: The amount of time it takes for the celestial sphere to rotate once
- D: The amount of time it takes for Earth to rotate once

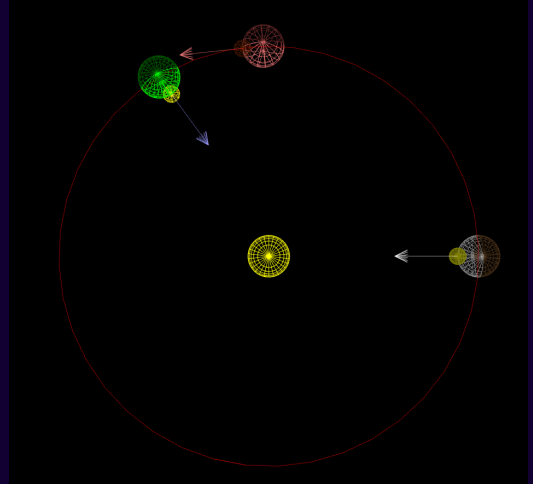
What is a day?

How should we define a *day*?

- A: $1/365$ of a year
- B: The amount of time from midnight to midnight, or noon to noon
- C: The amount of time it takes for the celestial sphere to rotate once
- D: The amount of time it takes for Earth to rotate once
- E: Aren't these all the same?

For illustration, let's imagine an Earth that turns very slowly, so it moves one-quarter of the way around the Sun in the time it takes to turn around once.

If the Earth is in the white position here, and the observer is the yellow dot (with the arrow sticking out of their head), what time is it?



A: Noon

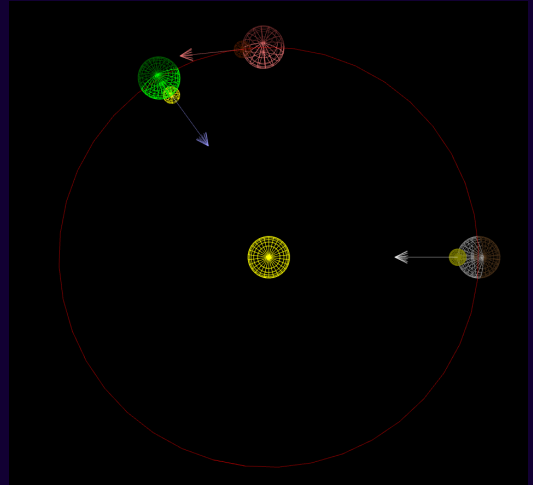
B: Midnight

C: Sunrise

D: Sunset

For illustration, let's imagine an Earth that turns very slowly, so it moves one-quarter of the way around the Sun in the time it takes to turn around once.

Which image shows the position of the Earth **exactly** one day after the “start” position (the white one)?

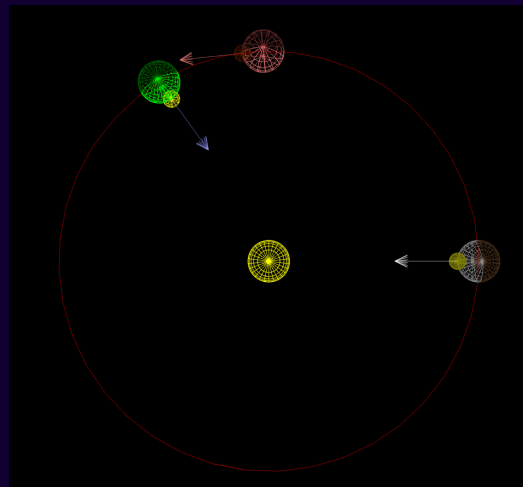


A: The red one

B: The green one

For illustration, let's imagine an Earth that turns very slowly, so it moves one-quarter of the way around the Sun in the time it takes to turn around once.

Which image shows the position of the Earth **exactly** one day after the “start” position (the white one)?



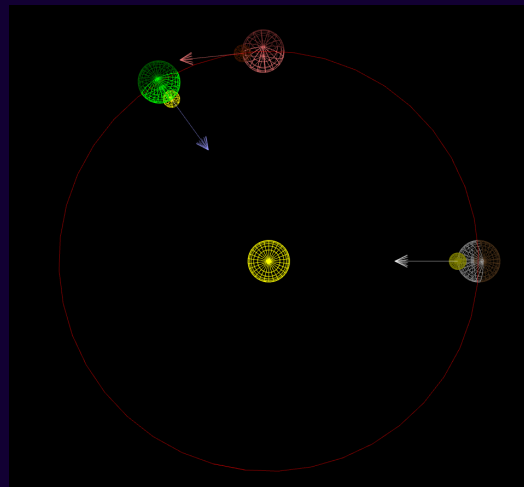
A: The red one

B: The green one

C: Depends on what you mean by “a day”

For illustration, let's imagine an Earth that turns very slowly, so it moves one-quarter of the way around the Sun in the time it takes to turn around once.

Which image shows the position of the Earth **exactly** one day after the “start” position (the white one)?



A: The red one

B: The green one

C: Depends on what you mean by “a day”

D: The Earth moves? BURN THE HERETIC!

There are *two kinds* of day!

- Solar day: judged by the position of the Sun
- Sidereal day (sih-dee-ree-al): judged only by the rotation of the Earth with respect to the stars

Two kinds of day!

Demo in *Stellarium*:

	Day by the stars	Day by the Sun
Earth	Rotates 360 degrees	Rotates 361 degrees
Stars	Return to same places	Slightly more than once around
Sun	Slightly less than once around	Returns to (almost) same place
Hours	23 hours 56 minutes	24 hours