Last Time on Survey of Astronomy

The “big picture”: The earth is:

- A single planet around a single star of hundreds of billions of stars.

- In a single galaxy of hundreds of billions of galaxies.

The earth, the sun, our solar system, our patch of the galaxy, and the galaxy itself are all moving at hundreds of thousands of km/h through the universe.

All of human history has occurred in the last minute of the calendar of the history of the universe.
Announcements/Reminders

- **Cell phones off please!**

- **New student?** Forgot to pickup tickets/syllabus/schedule last week? See me after class.

- **Class ID Form:** Turn in if still interested. Collins, Chen not on registration list.

- **In-class planetarium visit Sep 8th OR 10th. Details next wed.**
Assignments

For next week: Finish reading Chapter 2.

Finish up the “introduction to Mastering Astronomy” practice exercise.
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Finish up the “introduction to Mastering Astronomy” practice exercise.
A few notes on Mastering Astronomy

- **At least one practice problem each homework.**

- **Full Credit for answering correctly.**
  1/(n-1) off for each incorrect answer (better than regular multiple choice!).

- **2% “bonus” for not using a hint: rarely worth it!**

- **Stuck or need help? See me after class.**
Today’s Menu

- Units and numbers.
- Patterns of stars.
- Rising and Setting.
- Angles on the sky.
Units...

Not nearly as exciting as the Big Bang, but necessary

In the U.S., we basically use the British, or imperial, system of measurements

- LENGTH = FEET, YARDS, MILES, ETC.
- MASS = OUNCES, POUNDS
- TIME = SECONDS, MINUTES
Scientists use the metric system

- **Length** = Meters (m)

- **Mass** = Gram (g)

- **Time** = Seconds (sec)
Some Useful Conversions

- A meter is about the length of a yard
  
  \[ 1 \text{ m} = 1.094 \text{ yards} \]

- A kilometer (km) is 1000 m, a bit less than a mile
  
  \[ 1 \text{ km} = 0.62 \text{ miles} \]

- A meter per second (m/s) is about walking speed
  
  \[ 1 \text{ m/s} = 2.2 \text{ mph} \]

  \[ 1 \text{ km/s} = 2,200 \text{ mph} \]
**Metric Prefixes**

- **kilo** = 1000 (kilometer, kilogram, kilobuck)
- **milli** = 1/1000th (millimeter)
- **mega** = 1,000,000 (megabyte)
- **micro** = 1/1,000,000th (micrometer)

For more see Appendix C.4
Astronomers deal with very large and small numbers.

**VERY VERY BIG**

**VERY VERY SMALL**
Examples of Large and Small Numbers

- 2,560
- 456,000,000
- 36,000,000,000

- 0.1
- 0.00049
- 0.000000567

Warning: Writing these numbers out can induce hand cramping
Scientific Notation to the Rescue

Write a number like 3,456 as

\[ 3,456 = 3.456 \times 10^3 \]

How do we do that?

\[ 3.456 \times 1,000 = 3.456 \times (10 \times 10 \times 10) = 3.456 \times 10^3 \]
Examples of Scientific Notation

318,000,000  0.0000067
# Examples of Scientific Notation

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<thead>
<tr>
<th>Number</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>318,000,000</td>
<td>$3.18 \times 10^8$</td>
</tr>
<tr>
<td>31,800,000</td>
<td>$3.18 \times 10^7$</td>
</tr>
<tr>
<td>3,180,000</td>
<td>$3.18 \times 10^6$</td>
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<td>318,000</td>
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<td>$6.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>0.067</td>
<td>$6.7 \times 10^{-2}$</td>
</tr>
</tbody>
</table>

Confused? See Appendix C
Typing Numbers in Scientific Notation

On MasteringAstronomy, you get a text box with “buttons” for entering numbers.

$6.7 \times 10^{-5}$ can be typed as $6.7 \times 10^{-5}$
Observing the Sky:
The birth of astronomy
Why look at the sky?

- Knowing the time of day: **Survival skill**
  (many predators hunt at dusk!)

- Predicting seasons is a survival skill.
  - Migration
  - Food storing (like a squirrel)
  - Crop planting (last frost?)
  - Rains and droughts

- Nothing on TV.

- Eventually navigation, mapping.
Constellations and Star Maps
What are constellations?

- Patterns of stars.
- Examples: Ursa Major, Orion.
- Not: physical groups or clusters.
- A product of human imagination.

See also “that cloud looks like a bunny”.
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See also “that cloud looks like a bunny”.
THE HISTORY OF CONSTELLATIONS

Most ancient peoples had a system. They were not the same.

Ours came down from the Greeks, who got it from the Sumerians and Babylonians.

The International Astronomical Union recognizes 88 "official" constellations.
The history of constellations

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The International Astronomical Union recognizes 88 “official” constellations.
Chinese star chart
Thought Question

The brightest stars in a constellation

A) all belong to the same star cluster

B) all lie at about the same distance from the Earth

C) may actually be quite far away from each other
Thought Question

The brightest stars in a constellation

A) all belong to the same star cluster

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The Celestial Sphere

When we look out at the night sky, it appears we are sitting inside a large sphere.

The moon and stars all seem to be fixed on this (imaginary) ‘celestial sphere’
The Celestial Sphere

- The 3D Universe becomes two dimensional due to our perspective on Earth.

- The north and south pole of the Earth extend out to the north and south celestial poles.

- The equator of the Earth extends out to the celestial equator.
The Celestial Sphere

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The “North Star”

Nothing special, just where the celestial north pole happens to point.

Not the brightest star in the sky.

Will not always be the north star: tune in next week to find out why.
Why do the stars move?

- **The Earth Rotates** *(from W to E)*

- It appears to us as if the sky *(the Celestial Sphere)* rotates *(from E to W)*

- **Path of Stars**

- Stars “attached” to celestial sphere

- Path is a circle *(like latitude circle)*

- Called **diurnal circle** *(diurnal = daily)*
**Time of Day**

- **Meridian:**
  - Circle halfway between east and west
  - Stars, etc. are highest when they "Transit" the meridian

- **Time of day = solar position w.r.t. transit (Noon):**
  - AM = ante meridian
  - PM = post meridian

![Diagram of the meridian and time of day]

- 11 AM
- 10 AM
- 1 PM
- 2 PM
- Summer
- Winter

(6AM) E  W (6PM)
Rise / Set / Transit

- **Rise** - move above horizon (appear)
- **Set** - move below horizon (disappear)
- **Objects rise “in the east” and set “in the west”**
- **Transit** - moving past highest point in path
Circumpolar

Some stars never rise or set

These stars are circumpolar
Circumpolar

Some stars never rise or set

These stars are circumpolar

Polaris, The North Star
**Variation with Latitude**

To understand why the visible constellations vary with northward or southward travel, we must first review how we locate points on Earth (Figure 2.9). **Latitude** measures north-south position on Earth and is defined to be 0° at the equator and increases northward and southward. The North Pole and South Pole have latitudes of 90°N and 90°S, respectively. Note that “lines of latitude” are imaginary circles running parallel to the equator. **Longitude** measures east-west position, so “lines of longitude” are semicircles (half-circles) extending from the North Pole to the South Pole. By international treaty, the line of longitude passing through Greenwich, England, is defined to be longitude 0°. This line is called the **prime meridian**. Stating a latitude and a longitude pinpoints a location on Earth. For example, Rome lies at about 42°N latitude and 12°E longitude, and Miami lies at about 26°N latitude and 80°W longitude.

![Figure 2.9](attachment:image.png)

We can locate any place on Earth’s surface by its latitude and longitude. Latitude measures angular distance north or south of the equator. Longitude measures angular distance east or west of the prime meridian, which passes through Greenwich, England.

You can see why visible constellations vary with latitude by looking again at Figure 2.8b. If we move the person standing on Earth to a different latitude, it shifts the position of her horizon and zenith on the celestial sphere. For example, Figure 2.10 shows how the local sky appears relative to the celestial sphere for the latitudes of the North Pole (90°N) and Sydney, Australia (34°S).

![Figure 2.10](attachment:image.png)

The sky varies with latitude. Notice that the altitude of the celestial pole that is visible in your sky is always equal to your latitude.
How to Locate Objects in the Sky

Find NS / EW.

Objects are located by altitude above the horizon and direction along the horizon (e.g., NW)
Get out your workbooks

- Divide up into groups of 2-3 people.
- Go through the “Positions” exercise on page#1.
How much of the celestial sphere can an Earth observer see at one time?

A) less than half

B) exactly half

C) more than half
How much of the celestial sphere can an Earth observer see at one time?

A) less than half

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C) more than half
Imagine you are standing at the North Pole. Of the stars that you can see, roughly how many of these stars are circumpolar?

A) none
B) less than half
C) more than half
D) all
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**Review of Small Angles**

- **Full circle = 360 degrees**
- **1 degree = 60 arcminutes**
- **1 arcminute = 60 arcseconds**
How many arcseconds in 1 degree?

\[ 60 \text{ arcsec/arcmin} \times 60 \text{ arcmin/degree} = 3600'' \]
Angular size of the Moon is 0.5 degree

Complete circle = 360°
Some Other Useful Angular Sizes

- Sun = 0.5 degree = 30 arcminutes
- Moon = 0.5 degree = 30 arcminutes
- Resolution of your eye = 1 arcminute
How “big” is an object in the sky?

- Can you use inches or miles to estimate the size of the moon by looking at it?
- Angular size depends on distance.
- If you don’t know the distance to an object, you can’t know the true size.
- If you don’t know the true size, you can’t know the distance to it.
How can the Sun and Moon have the same angular size (30´)?

A) The Sun and the Moon are the same size

B) The Sun is much larger than the moon, but is also much farther away
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Recap

- **We assign objects positions on the “celestial sphere”, which stars appear to be fixed to.**

- **Our position on earth determines the constellations we see, and when we see them.**

- **Stars, the sun, the moon, and all the objects in the sky “rise” and “set” due to the rotation of the earth.**

- **Sizes of objects on the sky are measured as angles, not distances.**
Assignments

For next week: Finish reading Chapter 2.

Finish up the “introduction to Mastering Astronomy” practice exercise.