Earth is rotating on its own axis

- Earth is rotating counter-clockwise if you are looking at its North pole from other space.
- Earth is rotating clockwise if you are looking at its South pole from other space.

1 rotation every day (24 hours)
Because of the Earth’s rotation…

To the lion, celestial object A is rising at East from the horizon.
Because of the Earth’s rotation...

To the lion, celestial object A is high in the middle of the sky.
Because of the Earth’s rotation...

To the lion, celestial object A is setting at the West.
Because of the Earth’s rotation…

- Celestial objects rise (roughly) at East and set (roughly) at West.
- More precisely, all celestial objects are rotating about the line joining you and the star Polaris.
Because of the Earth’s rotation…

- The motion of all celestial objects in the sky is dominated by the Earth’s rotation.
- There is no exception, including the Sun.
Because of Sunrise and Sunset

When the Sun is above horizon: Day time
When the Sun is below horizon: Night time

To the lion, the Sun is rising at the East from the horizon.
Beginning of a day: approximately 6:00 a.m.
Because of Sunrise and Sunset

When the Sun is above horizon: Day time
When the Sun is below horizon: Night time

To the lion, the Sun is rising high in the middle of the sky.

Approximately Noon, 12:00 p.m  (closer to 12:30 p.m. EST in Lexington, because of our location in the Eastern time zone).
Because of Sunrise and Sunset

When the Sun is above horizon: Day time

When the Sun is below horizon: Night time

To the lion, the Sun is setting at the West. It will below the horizon after a while.

Beginning of evening: approximately 6:00 p.m.
Because of Sunrise and Sunset

When the Sun is above horizon: Day time
When the Sun is below horizon: Night time

To the lion, the Sun is at the other side of the Earth. It cannot see the Sun at all.

Midnight: 12:00 a.m.
In summary

The local time of every place on Earth is determined by the Sun position.
But the Moon is revolving around the Earth – once every ~ 30 days.

- The Moon will move in the manner similar to all other celestial objects over one day time, because of Earth’s rotation.
- However, over several days, the Moon’s motion in the sky will deviate from that of other stars because of the Moon’s revolution around the Earth.
Earth is rotating and Moon is revolving around Earth

The Moon is revolving around the Earth. One revolution in about 30 days (~ 1 month).
Both the Earth and Moon are lit by the Sun
Do not worry whether the Moon and the Earth will block sunlight from each other

- Earth and Moon are very small compared with Moon’s orbit. Earth: Basketball; Moon: Tennis Ball. These two balls are separated by a distance of 30 basket balls.

- Moon orbit is tilted at an angle of 5° with the Earth’s orbit, so they usually don’t get exactly between each other.

- Eclipses occur when the Earth and Moon are aligned with the sun rays.
When the Moon and the Earth kind of align with the sun ray, the Moon is actually way “high above” the Earth’s shadow.

Eclipses rarely occur. The dark part of the Moon we see commonly is NOT a result of Earth’s shadow or lunar eclipse.
A Myth

• If that is the Earth’s shadow, then this is a lunar eclipse and we will have a lunar eclipse every month!
• Earth’s shadow cannot produce the “Gibbous” appearance of the Moon:

This is NOT the Earth’s shadow!
Phases of Moon

Seeing the dark side of the Moon, i.e. nothing!
Phases of Moon

- Left side: fuzzy edge
- Right side: Sharp edge

Sun Light
Phases of Moon

What you will see: (waxing crescent)

Left side: fuzzy edge
Right side: Sharp edge

Sun Light
Phases of Moon – another example

Right side: fuzzy edge
Left side: Sharp edge

Sun Light

N.P.
Phases of Moon

What you will see:
(waning Gibbous)

Right side: fuzzy edge
Left side: Sharp edge
Phases of Moon

- New Moon
- Waxing Crescent
- Waxing Quarter
- Waxing Gibbous
- Full Moon
- Waxing Gibbous
- Waning Quarter
- Waning Crescent
- Waning Gibbous
- Waning Crescent

Sun Light
Phases of Moon – angle between Sun and Moon

- **Waxing Crescent**
  - Moon-Sun angle: 45°
- **Waxing Quarter**
  - Moon-Sun angle: 90°
- **Waxing Gibbous**
  - Moon-Sun angle: 135°
- **Full Moon**
  - Moon-Sun angle: 180°
- **Waning Gibbous**
  - Moon-Sun angle: 135°
- **Waning Quarter**
  - Moon-Sun angle: 90°
- **Waning Crescent**
  - Moon-Sun angle: 45°

**Sun Light**

- **New Moon**
  - Moon-Sun angle: 0°
Phases of Moon - Don’t forget about time!

The Moon is high at the sky to this place on Earth, which is at 12:00 p.m. (noon) now.
Phases of Moon - Don’t forget about time!

Sun Light

New Moon
High in sky: 12:00 p.m.
Rise: 6:00 a.m.  Set: 6:00 p.m.

To this place on Earth, the Moon rose 6 hours before and it will set 6 hours later.

N.P.

6:00 a.m.
12:00 a.m.
6:00 p.m.
12:00 p.m.
The Moon is high in the sky to this place on Earth, which is at 9:00 p.m. now.

Waxing Gibbous
High in sky: 9:00 p.m.
Phases of Moon - Another example

Waxing Gibbous
High in sky: 9:00 p.m.
Rise: 3:00 p.m.  Set: 3:00 a.m

To this place on Earth, the Moon rose 6 hours before and it will set 6 hours later.

Sun Light
Phases of Moon

New Moon
- High in sky: 12:00 p.m.
- Rise: 6:00 a.m.  Set: 6:00 p.m.
- Moon-Sun angle: 0°

Waxing Crescent
- High in sky: 3:00 p.m.
- Rise: 9:00 a.m.  Set: 9:00 p.m.
- Moon-Sun angle: 45°

Waning Crescent
- High in sky: 9:00 a.m.
- Rise: 3:00 a.m.  Set: 3:00 p.m.
- Moon-Sun angle: 45°

Waning Gibbous
- High in sky: 3:00 a.m.
- Rise: 9:00 p.m.  Set: 9:00 a.m.
- Moon-Sun angle: 135°

Waxing Gibbous
- High in sky: 9:00 p.m.
- Rise: 3:00 p.m.  Set: 3:00 a.m.
- Moon-Sun angle: 90°

Waxing Quarter
- High in sky: 6:00 p.m.
- Rise: 12:00 p.m.  Set: 12:00 p.m.
- Moon-Sun angle: 135°

Waxing Quarter
- High in sky: 6:00 a.m.
- Rise: 12:00 a.m.  Set: 12:00 p.m.
- Moon-Sun angle: 90°

Full Moon
- High in sky: 12:00 a.m.
- Rise: 6:00 p.m.  Set: 6:00 a.m.
- Moon-Sun angle: 180°

Sun Light

The Earth and Moon are revolving around the Sun at the same time - once every 365.25 days (1 year).

Note circular orbit.
Size

- Earth: basketball; Moon: tennis ball; Sun diameter: length of 110 basketballs, larger than the space between Earth and Moon.
Size

- Distance between Sun and Earth: length of 11900 basketballs (~2.3 miles)
Myth

• Summer and Winter cannot be a result of changing distance between Sun and Earth!
• If that is the case, then how can Australia be in Summer when we are in Winter?
Real reason for seasons

Tilted circular orbit (closer to side view)

Not to scale
The Earth is lit by the Sun

Tilted circular orbit (closer to side view)

N.P. “always” in day time

N.P. “always” at night

Not to scale
Different time in a year

- **Beginning of Spring:** March 21
- **Beginning of Summer:** June 21 (Summer Equinox)
- **Beginning of Fall:** September 21
- **Beginning of Winter:** December 21 (Winter Equinox)

Tilted circular orbit (closer to side view)

Not to scale
In a year, we are seeing different parts of the universe at night.
Where are we on the globe?

Beginning of Summer: June 21 (Summer Equinox)
Beginning of Spring: March 21
Beginning of Fall: September 21
Beginning of Winter: December 21 (Winter Equinox)

Tilted circular orbit (closer to side view)

Not to scale
Where are we on the globe?

Lexington at midday (noon)

North Pole

Equator

December 21

Lex

42°
Where are we on the globe?

- North Pole
- Equator
- 42°
- Lex
- December 21

Northern Hemisphere receives less sunlight than Southern Hemisphere
Where are we on the globe?

- **Sun Light**
- **North Pole**
- **Equator**
- **42°**
- **December 21**
- **65°**
- **Northern Hemisphere**
- **Southern Hemisphere**
- **Tropic of Capricorn**

Sun is directly overhead at this place.

Northern Hemisphere receives less sun light than Southern Hemisphere.
Here is what we see on ground
But everything is rotating about the line joining between you and the Polaris.
Now in the beginning of Summer

Beginning of Summer:
June 21 (Summer Equinox)

Beginning of Spring:
March 21

Beginning of Fall:
September 21

Beginning of Winter:
December 21 (Winter Equinox)

Tilted circular orbit (closer to side view)

Not to scale
Now in the beginning of Summer

Northern Hemisphere receives more sun light than Southern Hemisphere

June 21
Now in the beginning of Summer

Sun Light

North Pole

Equator

42°

23°

19°

Lex

N

S

Sun is directly overhead at this place

Northern Hemisphere

Southern Hemisphere

Northern Hemisphere receives more sun light then Southern Hemisphere

June 21
Here is what we see on ground

Path of Sun on Dec. 21

19°
But everything is rotating about the line joining between you and the Polaris.
In summary

<table>
<thead>
<tr>
<th>Date</th>
<th>Sunrise</th>
<th>Noon</th>
<th>Sunset</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 21</td>
<td>Northeast</td>
<td>South</td>
<td>Northwest</td>
</tr>
<tr>
<td>September 21</td>
<td>East</td>
<td>South</td>
<td>West</td>
</tr>
<tr>
<td>December 21</td>
<td>Southeast</td>
<td>South</td>
<td>Southwest</td>
</tr>
<tr>
<td>March 21</td>
<td>East</td>
<td>South</td>
<td>West</td>
</tr>
</tbody>
</table>
But everything is rotating

Path of Sun on Dec. 21
Path of Sun on March 21 and Sept 21
Path of Sun on June 21
Gnomon

Line joining tip of gnomon and tip of shadow
⇒ Sun ray
The shadow of a gnomon is pointing in the opposite direction to the position of the Sun in the sky.

Path of Sun on Dec. 21
Path of Sun on March 21 and Sept 21
Path of Sun on June 21
In summary (for Lexington)

In one day, the shortest shadow always occur at 12:00 p.m. (noon), due South.

March 21 and September 21

June 21 (longest path)

December 21 (shortest path)