Eclipses - Understanding Shadows

- An eclipse occurs when one astronomical object casts a shadow on the other.
  - Solar Eclipses – The Sun casts a shadow on the Earth
  - Lunar Eclipses – The Earth casts a shadow on the Moon
The Geometry of Shadows

- A shadow created from an extended source of light (e.g. The Sun) has two parts.
  - A dark umbra (“A”) in which all light from the Sun is blocked
  - A less shaded penumbra (“B”, “C”, “D”) where part of the light from the Sun is blocked.
Moon Phase and Eclipses

Because of the required alignment between Sun, Moon, and Earth, eclipses either happen at Full or New Moon:

- For a total solar eclipse the Moon is New.
- For a total lunar eclipse the Moon is Full.

Not to Scale!!!!
Why Eclipses are Rare

- The Earth and Moon, when seen to true scale, are tiny compared to their separation. Alignment must be nearly perfect.
  - The tilt of the Moon's orbit hinders that alignment.

If this figure were true to scale the Moon would be twice as far from the Earth!!
Why Eclipses are Rare

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- There are two times a year, separated by 6 months, when the shadows line up.
Solar Eclipses

- Solar eclipses occur when the Moon blocks the Sun from view.
  - The Moon must be New.
  - The total eclipse can be seen from a limited set of locations.
Solar Eclipses

- The tapering umbral shadow of the Moon just barely reaches Earth (sometimes it doesn't – an annular eclipse)
  - The Moon's umbral shadow is small – covering a couple of hundred miles at best.
Solar Eclipses

- The Moon's orbital motion and Earth rotation sweep the shadow across the Earth in a matter of hours.
  - Locations along this eclipse path experience “totality” for a few minutes at best.

Total Solar Eclipse of 1999 August 11
Solar Eclipses

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Solar Eclipses

- Despite the short duration and remote location, people go to extremes to view eclipses.
  - Phenomena that are usually washed out by the blue sky become visible – the solar corona and solar prominences.

http://www.mreclipse.com/
Note the nearly identical eclipses 18+ years apart. The Moon's exact position repeats relative to the Earth and Sun every 18 years creating a family of eclipses – the Saros cycle.
Solar Eclipses from Charlottesville?

- You have to wait several hundred years on average for a total solar eclipse to happen at your location.
- Partial eclipses, which cover more area, are common however.

Total and Annular Solar Eclipse Paths: 1501–1520
Eclipses in the Next Century
Eclipses on Other Worlds

- The outer planets have lots of moons...
Lunar Eclipses

- The Earth casts a shadow on the Moon
  - To be specific, the Moon moves through the Earth's shadow
Lunar Eclipses

- The Moon takes a couple of hours to cross the Earth's shadow.
  - The Earth's umbral shadow is large enough to consume the whole Moon.
Lunar Eclipses

- Everybody on the night side of the Earth can see the eclipse.
Lunar Eclipses

- The Moon takes on a reddish hue during the total eclipse because of light refracted through the Earth's atmosphere.
  - This is the combined light of all of the world's sunrises and sunsets!

The View from the Moon
Annular vs. Total Eclipses

- The Moon follows an elliptical orbit.
  - When it is close to the Earth it easily covers the Sun (total eclipse) when far away its angular size is smaller than the Sun's (annular eclipse).
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Annular vs. Total Eclipses

- So much Sun is visible during an annular eclipse that none of the spectacular solar eclipse phenomena is visible.