Features of the Earth’s Moon

- Second-brightest object in the sky
- Average distance 240,000 mi
  - 380,000 km
  - Features can be seen with the unaided eye
- Fifth largest moon in solar system
- Very nearly spherical
  - Slightly oblate
    - Difference in diameter at equator vs poles 1.5 km

Features of the Earth’s Moon

- Slight asymmetry in the crust
  - Thicker on the ‘far’ side
- Mass \( \frac{1}{81} \) the mass of Earth
  - \( g \) is about \( \frac{1}{6} \) that of Earth
- No current magnetic field
  - May have been one in the past!

Craters

- Majority (99%) of craters are impact craters.
  - Other craters are volcanic.
  - Material around rim approximately equal to volume of crater

Basin

- Flattened interior of large craters
- South Pole / Aitkin Basin
  - Multi impact craters
  - 2500 km diameter,
    - 12 km depth at South Pole keeps in shadow
      - Hope to find water!
  - Schrodinger Basin
    - One of the most recent impact basins.
**Plains**
- Dark areas
  - Low albedo
  - Lava flows
- Regolith
  - Covers surface of the Moon
  - Loose debris
  - More on highlands
  - Older!

**Rays**
- Streaks of lighter material from craters
  - Powdered rock
  - Darkens with time
    - Areas that cross, lighter material is always on top

**Lunar Features**
- Rills
  - Long, narrow valleys caused by moonquakes.
- Mountain Ranges
  - Circular patterns surrounding the plains
  - Different formation process than earth
- Faults
  - Break in the surface
  - Several observed

**Features of the Earth’s Moon**
- Learning Goal:
  - Describe the general physical properties of the Moon.
- Questions:
  - 1 – 4
- Exercises:
  - 1

**Lunar Motion Effects**
- Revolves around the Earth in 29.5 days
- Rotational period is 29.5 days
  - Only see one side from Earth
    - No ‘Dark Side’ of the moon
    - David Gilmour is NOT a lunar expert!
  - Month with no full moon
    - Blue Moon – Second full moon in a month
- Sidereal month 27.3 days
  - Shorter for same reason sidereal day shorter than synodic day
- Orbital plane tilted relative to orbital plane of Earth around Sun

**Phases of the Moon**
- Reflected light
- Phase depends on the relative position of the Sun, Earth and Moon
- Moonrise a function of the phase of the moon
  - New moon parallels the sun
  - Full moon opposite
Phases of the Moon

- **New**
  - Only for an instant
- **Waxing Crescent**
  - Less than ½ of the side of the Moon visible from Earth is illuminated - increasing (right side as seen from Earth)
- **First Quarter**
  - Exactly ½ of the side of the Moon visible from Earth is illuminated (right side)
  - Only for an instant
- **Waxing Gibbous**
  - More than ½ but less than Full Moon (increasing - right)
- **Full Moon**
  - Only 'full' for an instant
- **Waning Gibbous**
  - More than ½ but less than Full Moon (decreasing - left)
- **Last Quarter**
  - Exactly ½ of the side of the Moon visible from Earth is illuminated (right side)
  - Only for an instant
- **Waning Crescent**
  - Less than ½ of the side of the Moon visible from Earth is illuminated – decreasing (left side as seen from Earth)

New Moon…

Eclipses

- Occurs when shadow is observed
  - **Solar eclipse**
    - Sun is blocked from Earth by the Moon
  - **Lunar Eclipse**
    - Sun is blocked from the Moon by the Earth

Solar Eclipse

- Occurs during new moon
- **Umbral**
  - Completely blocked from the Sun
  - 'Total Eclipse'
- **Penumbra**
  - Partial blockage
  - Much larger area
- Relative size of Moon and Sun (from Earth) very close!
Solar Eclipse

- Annular Eclipse
  - Occurs when umbra doesn’t reach the surface of the Earth
  - Moon doesn’t completely block out Sun, leaves a bright ring
  - Last total eclipse observed in OK was annular

Eclipses

- Do not occur every new moon because the orbit of the moon is tilted 5° to the ecliptic.
  - Points where orbit of the Moon crosses the ecliptic are called nodes.
  - Ascending and Descending

Eclipses

- Solar eclipse will only occur when node coincides with new moon.
- Lunar eclipse will only occur when node coincides with full moon.

Lunar Eclipse Progression

Ocean Tides

- Observed for centuries
- First related to the Moon in 1st century AD
  - Tides greatest when the Moon was directly overhead.
- Explained by Newton’s law of universal gravitation
  - Gravitational attraction of the Moon and Sun
  - Does NOT “suck water towards the Moon!”
**Tidal Bulges**

- Occurs because of differential gravitational attraction for different points on the Earth
- Water flows more easily than solid
  - Makes observation of the tidal bulges much easier
- Two high tides per day
  - Moon approx. over meridian and opposite meridian

**Tides**

- Spring tide
  - Moon's gravity is enhanced by being in a line with the sun
  - Results in a higher tide
- Neap tide
  - Sun is perpendicular to the position of the Moon
  - Tidal effect is slightly moderated

**Tidal Forces**

- Causes a decrease in the rate of the rotation of the Earth
  - 0.002 seconds per century
  - Decrease in angular momentum
- Conservation of energy
  - Must increase angular momentum for the Moon
  - Semimajor axis increasing by about 1.3 cm/yr
- 1 billion years ago, days were shorter (5.6 hr) and the Moon was closer (8,100 mi)
  - Eventually, will be only annular solar eclipses!

**Lunar Motion Effects**

- **Learning Goals:**
  - Define and explain the phases of the Moon
  - Describe and explain solar and lunar eclipses.
  - Define and describe tidal force.
  - Explain ocean tides.
- **Questions:** 5 – 16
- **Problems:** 3 – 13 odd
Asteroids, Meteoroids, Comets, and Interplanetary Dust

- Outer limit of the Solar System is considered to be about 100,000 AU
  - Point that the Sun's gravitational field balances the gravitational field of the Milky Way.
  - Objects influenced by the Sun's gravity:
    - Asteroids
    - Meteoroids
    - Comets
    - Dust...

Asteroids

- Minor Planet
- Largest is Ceres
- Only one can be seen w/o magnification
- Diameters from 940 km to just a few km
- Billions of smaller particles!
- Prograde rotation
- Believed to be material that didn’t coalesce into a planet.

Meteoroids

- Interplanetary junk.
  - Asteroids, comet material, ...
  - Sizes range from mm to km
- Meteor
  - Strikes Earth's atmosphere
  - 'Shooting Stars'
- Meteorite
  - Survives to the Earth's surface.

Meteorites

- Largest had a mass of more than 55,000 kg
- 3 types
  - Stones
    - 94% of all meteorites that strike the Earth
    - Similar in composition to rocks on Earth
  - Irons
    - Mostly iron with 5-20% nickel
  - Stony-Irons
    - Mix of both types

Comets

- 'Long-haired stars'
- Very elliptical orbits
- Mainly dust and ice
  - Silicate or metallic dust
  - $\text{H}_2\text{O}$, $\text{CO}_2$, $\text{NH}_3$, $\text{CH}_4$ ice
- Consists of 4 parts
**Comet Parts**
- **Nucleus**
  - Dust and ice core
  - Typically a few km
- **Coma**
  - Bright area around the nucleus
- **Tail**
  - Ions and dust
- **Hydrogen cloud**

**Comets**
- Visible by reflected sunlight
- Becomes more visible closer to the Sun
  - More reflected light
  - The coma and tail increase dramatically in size
    - Probably due to heating of the ice parts of the nucleus
- Tail always points away from the sun
  - Probably driven by the ‘solar wind’

**Halley’s Comet**

**Interplanetary Dust**
- Very small particles
- Micrometeoroids
- Can be seen under the right conditions
  - Zodiacal light
    - Band of reflected light at the ecliptic
    - Apparent path of the sun
    - Visible just before sunrise or after sunset
  - Gegenshein
    - Due to dust particles opposite the Sun’s position

**Asteroids, Meteoroids, Comets, and Interplanetary Dust**
- **Learning Goal:**
  - Describe asteroids, meteoroids, comets, and interplanetary dust.
- **Questions:** 28 - 33
- APPLICIBLE Key Terms; Matching, Multiple Choice, and Fill-in-the-Blank
  - Questions; Visual Connection and Applying your Knowledge