General Physical Science

Chapter 15
Place and Time

Space and Time

- Einstein
  - Space and time related
    - Single entity
    - Time is the 4th dimension!

Cartesian Coordinates

- Need some system to tell us where something is
- One – dimensional
  - Elevator
  - Number Line
Cartesian Coordinates

- Need two dimensional system
  - 2 number lines perpendicular to each other
    - X-axis is horizontal
    - Y-axis is vertical
  - Position relative to both number lines!

Cartesian Coordinates

- Named after Rene’ Descartes
- Use to locate any position on Earth
  - IF the earth was flat!
- Must ‘modify’ the system to account for a spherical shape.
  - Lines become circles

Cartesian Coordinates

- Learning Goal:
  - Explain the Cartesian coordinate system.
- Questions:
  - 1 - 3
Latitude and Longitude

- Modifies Cartesian coordinates for spherical shape of the Earth
- Latitude
  - Measurement of North and South displacement (Y-axis)
  - Use the poles to define top and bottom Points for axis of rotation
  - Series of concentric circles Rotational axis is the center of the circles

Latitude

- Diameter of circles will vary to a point at the poles!
  - Equator – 0°
  - North Pole - 90°N
  - South Pole - 90°S
- Also known as ‘parallels’
  - Infinite number!
  - Following a parallel will take you due East or West.

Meridians

- Measure of East and West displacement (X-axis)
- Half circles connecting the poles.
  - ½ of a ‘great circle’ Circle with center at the center of the Earth
    - Only parallel that is a great circle is the Equator
  - Perpendicular to parallels.
Meridians

- Measured in angular displacement from the Prime Meridian.
  - Meridian that passes through Greenwich, England.
- Prime meridian is defined as 0°.
  - Meridian that ‘completes’ the circle is 180°.
  - All others are measured as degrees east or west of the Prime Meridian

Meridians and Parallels

Latitude and Longitude

- Meridians run exactly North and South
- US – Latitude is N; Longitude is W
  - Lawton is 34.57°N; 98.42°W
- Also express as Degrees/Minutes/Seconds
  - 1 degree = 60 minutes; 1 minute = 60 seconds
  - Lawton is 34° 34’ 4” N; 98° 25’ 0” W
Great Circle

- Shortest distance between 2 points on a sphere.
  - 1 minute of arc = 1 nautical mile (nm)
    - 1 nm = 1.15 statute miles
    - Change in 1 minute on meridian is 1 nm
      - Change in 1° N or S is 60 nm
      - NOT TRUE for parallels
  - Show great circle path by stretching a string on a globe
    - Shows why flights to Tokyo from Los Angeles go near Anchorage

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Determine the number of nautical miles between A (10°S, 90°W) and B (70°N, 90°E)

- All points are on the same great circle formed by the 90°W, 90°E meridians
- Total displacement
  - 10°S to equator = 10°
  - 0° to 90°N (on 90°W meridian) = 90°
  - 90°N to 70°N (on 90°E meridian) = 20°
  - 10° + 90° + 20° = 120°
  - 120° × 60 nm/degree = 7,200 nm
  - BOOK EXAMPLE WRONG!!

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Mercator

- Mapmaker
  - Still most common projection of a spherical surface on a 2 dimensional surface!
  - Defined an atlas as a collection of maps.
    - Map is a diagram that shows the relative position of objects on the surface of the Earth
  - Frame of reference for maps is Lat/Lon
Global Positioning System

- Based on measurement of time
  - Time it takes for a signal to get from a satellite to the receiver
  - 24 satellites currently make up the GPS 'constellation'
  - Not all visible at any time

Global Positioning System

- Position of satellites known very accurately
- Time delay is due to distance
  - Signal travels at the speed of light
- To determine position we need signal from at least 3 satellites
  - For altitude we need at least 4
Latitude and Longitude

- **Learning Goals:**
  - Define and explain *latitude* and *longitude*.
  - Solve latitude and longitude exercises relative to the surface of the Earth.
  - Describe how the Global Positioning System functions.
- **Questions:** 8 – 18
- **Problems:** 1 – 7 odd

Time

- Continuous forward flowing of events
- Base unit for time is the second
  - Interval for an isotope of cesium ($^{133}$Cs) to vibrate 9,192,631,770 times.
- All other time units based on the second
  - Minutes, hours, days…

Solar Day

- Elapsed time between successive apparent crossings of the same meridian.
  - Function of rotation and revolution
  - NOT CONSTANT! Orbital speed varies.
- **Mean Solar Day**
  - Average of all solar days in a year
**Solar Day**

- Different than sidereal day
  - Time for star other than sun to cross specified meridian
- For a solar day, Earth must rotate more than 360°.

**Local Solar Noon**

- Sun exactly over the local meridian
  - No east or west displacement in the position of the Sun.
  - AM (ante meridian)
    - Before the meridian
  - PM (post meridian)
    - Beyond the meridian
- Either 12 noon or 12 midnight
  - NOT 12 am or 12 pm!

**Standard Time Zones**
Standard Time Zones

- 24 time zones
  - Centers theoretically 15° apart
  - Some adjustments for local political reasons
  - Lawton would be in the Mountain time zone with a strict interpretation!

- First time zone at Prime Meridian
  - Greenwich Mean Time (GMT)
  - Now UTC
    - Synchronized to Atomic Clocks

International Date Line

- Needed to keep days constant for long distance travelers.
  - Leave LAW on the Concorde at local Solar noon
  - Travel west with the sun always above your meridian
  - On landing, no 'day' has passed for you
  - Define change of day at 180°
    - International Date Line (some political changes)
    - Ahead 1 day when traveling to the West
    - Back 1 day when traveling to the East

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**Daylight Savings Time**

- First used in WWI to conserve fuel used to generate electricity
  - Still standard practice for most states in the US
- 2 a.m. second Sunday in March to 2 a.m first Sunday in November.
  - NOT universal
  - Different countries have different time frames

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**Time**

- Learning Goals:
  - Interpret the concept of time
  - Explain the necessity for time zones and the International Date Line.
- Questions: 11 – 18
- Problems: 9 – 15 odd

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**Determining Latitude and Longitude**

- Interesting stuff, but we can skip it!
Seasons and the Calendar

- Start of seasons defined by Sun’s apparent position
  - Changes due to the tilt of the Earth
- Solstice
  - Summer – Sun perpendicular to 23.5°N
    - Tropic of Cancer (Northern Hemisphere)
    - June 21 or 22
  - Winter – Sun perpendicular to 23.5°S
    - Tropic of Capricorn (Southern Hemisphere)
    - December 22 or 23

The Seasons

- Winter solstice is the ‘official’ start of winter, and summer solstice is the ‘official’ start of summer.
- Equinox
  - Sun is perpendicular to equator
    - Vernal – Spring (March 20 or 21)
    - Autumnal – Fall (September 22 or 23)
Daylight Hours

- Equinox – All areas of Earth get 12 hours of sunlight.
- Because of the tilt of the Earth, in the summer days are longer than 12 hours.
  * Combined with more direct contact of sunlight, summers are warm/hot!
- Winter days – less than 12 hours.
  * Also less direct sunlight – colder!

Distribution of Daylight

Year

- Tropical Year
  * Time from one vernal equinox to the following vernal equinox
  * 365.2422 days
- Sidereal Year
  * One revolution around the sun with respect to any star other than the Sun
  * 365.2536 days
The Calendar

- **Day**
  - Defined by sun cycle
- **Month**
  - Defined by lunar cycle
- **Year**
  - Defined by seasonal cycle
- **Zodiac**
  - Based on 12 constellations
  - Appearance in night sky marked different times of year
  - Precession caused slow change in time of appearance!

The Calendar

- **Moon probably greatest influence**
  - Babylonians
    - Prior to 3000 BC
    - 30 days per month
    - Would periodically add another month when needed!
- **Week**
  - Probably time for moon to go from one phase to the next
- **BC and AD**
  - New terminology BCE and CE
  - Same time frame as BC and AD

The Calendar

- **Questions: 22 – 29**
Precession of the Earth’s Axis

- Wobble
  - Top
- Center of gravity not exactly in line with the axis of rotation
- Occurs with Earth!

Questions: 30 – 32

Key Terms; Matching, Multiple Choice, and Fill-in-the-Blank Questions; Visual Connection and Applying your Knowledge