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Tides
- 2  **a little tidal haiku:**
 - *the tide rushes in*
 - *essential for life on Earth*
 - *all thanks to Luna*
- 3  **What Are Tides?**
 - Tides – periodic raising and lowering of ocean sea level
 - Occur daily
 - Isaac Newton's gravitational laws explain relationship
 - Tides recognized even by early sailors
- 4  **Tide-Generating Forces**
 - Barycenter between Moon and Earth
 - Common center of mass or balance point
 - Beneath Earth's surface because of Earth's greater mass
- 5  **Gravitational Forces**
 - Every particle attracts every other particle
 - Gravitational force proportional to product of masses
 - Increase mass, increase force
 - Inversely proportional to square of separation distance
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- 6  **Gravitational Forces**
 - Greatest force at zenith – closest to moon
 - Least force at nadir – furthest from moon and opposite zenith
- 7  **Centripetal Force**
 - Center-seeking force
 - Tethers Earth and Moon to each other
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- 8  **Resultant Forces**
 - Mathematical difference between gravitational and centripetal forces
 - Relatively small
- 9  **Tide-Generating Forces**
 - Resultant force has significant horizontal component
 - Pushes water into two simultaneous bulges
 - One toward Moon
 - One away from Moon
- 10  **Tidal Bulges – Moon's Effect**
 - Small horizontal forces push seawater into two bulges.
 - Opposite sides of Earth
- 11  **Idealized Tidal Bulges**
- 12  **Tidal Phenomena**
 - Tidal period – time between high tides
 - Lunar day
 - Time between two successive overhead moons
 - 24 hours, 50 minutes
 - Moon orbits Earth
 - High tides are 12 hours and 25 minutes apart
- 13  **Tidal Bulges – Sun's Effect**
 - Similar to lunar bulges but much smaller
 - Moon closer to Earth
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- 14  **Earth's Rotation and Tides**

- Flood tide – water moves toward shore
- Ebb tide – water moves away from shore
- Tidal bulges are fixed relative to the Sun's and Moon's positions
 - Earth's rotation moves different geographic locations into bulges
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- 15  **Monthly Tidal Cycle**
 - Spring tides
 - New or full moons
 - Tidal range greatest
 - Syzygy (def. - conjunction or opposition)
 - Neap tides
 - Quarter moons
 - Tidal range least
 - Quadrature
- 16  **Tidal Cycle**
- 17  **Earth, Moon, and Sun Positions Relative to Spring and Neap Tides**
- 18  **Complicating Factors**
 - Declination – Angular distance of the Moon or Sun above or below Earth's equator
 - Sun to Earth: 23.5 degrees north or south of equator
 - Moon to Earth: 28.5 degrees north or south of equator
 - Lunar and solar bulges shift from equator
 - Unequal tides
- 19  **Scripps Pier Tides, 14 April 2014**
- 20  **Declination and Tidal Bulges**
- 21  **Predicted Idealized Tides**
- 22  **Complicating Factors**
 - Elliptical orbits
 - Earth around Sun:
 - Tidal range greatest at perihelion (January)
 - Tidal range least at aphelion (July)
 - Moon around Earth:
 - Tidal range greatest at perigee (Moon closest to Earth)
 - Tidal range least at apogee (Moon furthest from Earth)
 - Perigee–apogee cycle is 27.5 days
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- 23  **Effects of Elliptical Orbits**
- 24  **Idealized Tide Prediction**
 - Two high tides/two low tides per lunar day
 - Six lunar hours between high and low tides
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- 25  **Real Tides**
 - Continents and friction with seafloor modify tidal bulges
 - Tides are shallow-water waves with speed determined by depth of water
 - Idealized tidal bulges cannot form
 - Cannot keep up with Earth's rotation
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- 26  **Real Tides**
 - Crests and troughs of tides rotate around amphidromic point
 - No tidal range at amphidromic points
 - Cotidal lines – connect simultaneous high tide points
 - Tide wave rotates once in 12 hours
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- 27  **Cotidal Map**
- 28  **Tidal Patterns**
 - Diurnal
 - One high tide/one low tide per day
 - Semidiurnal
 - Two high tides/two low tides per day
 - Tidal range about same
 - Mixed
 - Two high tides/two low tides per day
 - Tidal range different
 - Most common
- 29  **Tidal Patterns**
- 30  **Monthly Tidal Curves**
- 31  **Tides in Coastal Waters**
 - Standing Waves
 - Tide waves reflected by coast
 - Amplification of tidal range
 - Example: Bay of Fundy maximum tidal range 17 meters (56 feet)
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- 32  **Bay of Fundy – World’s Largest Tidal Range**
- 33  **Bay of Fundy Tides**
- 34  **Tides in coastal waters**
 - Ripple Rock, Seymour Narrows
 - Tide flows through a narrowing channel
 - North of Campbell River, British Columbia
 - Top of Ripple Rock was 9 feet below the surface before being blown up by the “world’s largest non-nuclear explosion” in 1958
 - Still requires skill to negotiate!
- 35  **Ripple Rock, Seymour Narrows**
- 36  **CBC coverage, 5 April 1958**
- 37  **Tides in Coastal Waters**
 - Tidal Bores
 - Wall of water
 - Moves up certain rivers
 - Tide-generated
- 38  **Coastal Tidal Currents**
 - Rotary Current
 - Reversing current
 - Flood current
 - Ebb current
 - High velocity flow in restricted channels
 - No current at high slack water or low slack water
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- 39  **Coastal Tidal Currents**
- 40  **Coastal Tidal Currents**
 - Whirlpool
 - Rapidly spinning seawater
 - Restricted channel connecting two basins with different tidal cycles
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- 41  **Tides and Marine Life**
 - Tide pools and life
 - Grunion spawning

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- 42  **Tide-Generated Power**
 - Does not produce power on demand
 - Possible harmful environmental effects
 - Renewable resource
 - First Asian power plant in 2006
 - United Kingdom proposed building world's largest tidal power plant
- 43  **Power Plant at La Rance, France**
 - Successfully producing tidal power since 1967
- 44  ***End of CHAPTER 9***
Tides