Lec 10: 28 September 2011  Chapter 4: Tides

Last – Newton’s Laws of Motion; Orbits

Today – Other Effects of Gravity

• More about orbits
• All about Tides

Next - Overview and Formation of Solar System
Read Chapter 7; Pre-Quiz Monday
Read Chapter 8 by Wednesday

Exam #1 Results
average...... 61
maximum... 88

Letter grade is purely advisory; numbers will be averaged
Final scale will be very similar to this scale
In-class counts 25%
Lowest score dropped if you take the final

Circular Orbit:
\[ v_{orb} = \sqrt{GM/r} \]

Earth rotation: 0.5 km/s (1,037 mph)
s/c around Earth: 8 km/s (17,668 mph)
Earth around Sun: 30 km/s (66,634 mph)

Escape Velocity:
\[ v_{esc} = \sqrt{2v_{orb}} \]
S/C around Earth: 11.1 km/s
Earth around Sun: 41.7 km/s

Earth-Orbiting Spacecraft

• Earth rotates west-->east at 0.5 km/s
  – that’s why we launch toward the East
  – unless we want a “polar” orbit

• Circular velocity ~16 times rotational velocity
  – so orbit 16 times in 24 hours (Period ~90 minutes)
  – “low-earth orbit”
  – farther out -> slower

• Circular orbit at 6.6 R_E is “geosynchronous” (Period = 24 hours)
  – how do we get to geosynchronous orbit?
Interplanetary Travel

- “perigee”/“perihelion” closest to Earth/Sun
- “apogee”/“aphelion” furthest from Earth/Sun
- moves fastest at peri- slowest at ap-

- In lab next week: Interplanetary trajectory
  - e.g. Gravity-Assist (slingshot) trajectories

Gravity and the Solar System

- Sun’s gravity dominates motions in the solar system
  - nothing flying around free
  - everything orbiting Sun
  - all the major stuff orbiting the same direction
  - all the major stuff orbits in Sun’s equatorial plane
- Gravity pulls large objects into a spherical shape
  - small objects can have irregular shapes, but
  - planets, large moons, and the Sun are all spherical

- When large objects are relatively close together (e.g. Earth and Moon), the effective pull of gravity is not the same everywhere on their surfaces: TIDES

Properties of Tides

- 2 high tides, 2 low tides each day (most places)
- water tides much larger than solid Earth tides
- timing and amplitude of tides are linked to the PHASE of the Moon
  - strongest at Full and New Moon (i.e. highest highs, lowest lows)
  - weakest at 1st and 3rd Quarter (i.e. lowest highs, highest lows)
- they are also linked to the position of the Moon and the Sun in the sky!
  - high tide when Moon is near meridian (usually, but not in CHS)
  - low tide when Moon is near horizon
  - where is Sun when Moon is on Meridian? Horizon? depends on phase of Moon!

- Tides occur about 50 minutes later each day
  - recall that the Moon rises ~50 minutes later each day!
- Local geography alters timing of tides
  - position in time zone (i.e. local solar time v. civil time)
  - shape of ocean floor
  - shape of shore line
  - always a few hour lag
    - high tide when Moon ~1 hour past meridian
    - in Charleston it’s more like 4 hours past the meridian!
  - “Resonances” can lead to huge tides...
- Note: “Tidal Waves” have nothing to do w/ tides!
### Tides and Moon Phases

**Tides:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Tide</th>
<th>Water Level</th>
</tr>
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<tbody>
<tr>
<td>0252</td>
<td>Low</td>
<td>-0.4</td>
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<tr>
<td>0912</td>
<td>High</td>
<td>7.1</td>
</tr>
<tr>
<td>1526</td>
<td>Low</td>
<td>-0.3</td>
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<tr>
<td>2129</td>
<td>High</td>
<td>6.5</td>
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1d past New Moon:

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>Sunrise</td>
<td>0711</td>
</tr>
<tr>
<td>Moonrise</td>
<td>0830</td>
</tr>
<tr>
<td>Sunset</td>
<td>1908</td>
</tr>
<tr>
<td>Moonset</td>
<td>1947</td>
</tr>
</tbody>
</table>

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**Bay of Fundy**

“Tidal Bore” at Turnagain Arm of the Cook Inlet

Here’s a true “tidal” wave