Announcements

• Final exam will be Thursday, May 1st, from 9-12AM.
• Makeup times
  - Friday May 2nd from 9-12, room 120
  - Monday May 5th from 2-5, room 120
• To be posted shortly:
  - Final study guide
  - Lectures 34-37.
  - Last years final.
Medical Imaging

• X-ray based techniques
  – Conventional
  – “Computed Tomography” or CT Scans

• Magnetic Resonance Imaging
**Computed Tomography (CT) scan of head**

### Table I - Radiation Dose Comparison

<table>
<thead>
<tr>
<th>Diagnostic Procedure</th>
<th>Typical Effective Dose (mSv)&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Number of Chest X rays (PA film) for Equivalent Effective Dose&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Time Period for Equivalent Effective Dose from Natural Background Radiation&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest x ray (PA film)</td>
<td>0.02</td>
<td>1</td>
<td>2.4 days</td>
</tr>
<tr>
<td>Skull x ray</td>
<td>0.07</td>
<td>4</td>
<td>8.5 days</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>1.3</td>
<td>65</td>
<td>158 days</td>
</tr>
<tr>
<td>I.V. urogram</td>
<td>2.5</td>
<td>125</td>
<td>304 days</td>
</tr>
<tr>
<td>Upper G.I. exam</td>
<td>3.0</td>
<td>150</td>
<td>1.0 year</td>
</tr>
<tr>
<td>Barium enema</td>
<td>7.0</td>
<td>350</td>
<td>2.3 years</td>
</tr>
<tr>
<td>CT head</td>
<td>2.0</td>
<td>100</td>
<td>243 days</td>
</tr>
<tr>
<td>CT abdomen</td>
<td>10.0</td>
<td>500</td>
<td>3.3 years</td>
</tr>
</tbody>
</table>

1. Effective dose in millisieverts (mSv).
2. Based on the assumption of an average "effective dose" from chest x ray (PA film) of 0.02 mSv.
3. Based on the assumption of an average "effective dose" from natural background radiation of 3 mSv per year in the United States.
Most subatomic particles behave as if they were tiny magnetized tops

Spin is familiar in macroscopic objects such as planets. Fundamental particles also behave as if they have spin.

Thus ....

- Particles behave like tiny spinning tops ....
- .... that are also tiny bar magnets.
A spinning top

A spinning top, not subject to any other forces, will just sit there and spin, maintaining its orientation.
Precessing Tops

If the spinning top is subject to a force, such as gravity, it will begin precessing about the axis along which that force is applied.
A spinning top that is also a magnetic dipole will precess about the axis of the magnetic field.

Here the north pole experiences a downward force and the south pole experiences an upward force.

But ONLY if the spin is tipped with respect to the magnetic field.
How does magnetic resonance (MR) work?

STEP #1:
• A large magnetic field aligns the “spins” or magnetic moments of the protons (in hydrogen atoms) in our bodies.

(Actually, only a few per million are lined up, but that turns out to be enough!)
How does MR work?

STEP #2:

- Radio waves are transmitted into our bodies at just the right frequency.
- The spins in our body are then tipped and begin precessing.
How does MR work?

STEP #3:

- Radio waves are then re-emitted from our bodies and detected by receivers.
How does MR imaging (MRI) work?

- The spins are only tilted when there the radio frequency is just right for the particular magnetic field.
- The radio waves that are emitted have different frequencies depending on the magnetic field.

By applying various magnetic field “gradients” both when tipping the spins (hitting the patient with radio waves) and when listening (detecting the emitted radio waves), computers can reconstruct the distribution of protons in the body.
MRI images of a human head
What are the strengths and weaknesses of CT and MRI?

**CT**
- Uses X-rays, which are a form of ionizing radiation.
- Imaging is based on the degree to which different tissues absorb X-rays. Particularly good sensitivity to heavier elements.

**MRI**
- Based on “tipping” or exciting spins in the body using radio waves, which are not a form of ionizing radiation.
- Must be done in a large magnetic field, which is not possible for people with pacemakers and some other devices.
- Tends to be most sensitive to “soft tissues” that contain a great deal of water.