New International Energy Outlook 2011 – came out yesterday

- World energy consumption increases by 53% between 2008 and 2035 with half of the increase attributed to China and India
  - (last year’s estimate was 48%)
- Renewables are the world’s fastest-growing energy source, at 2.8% per year; renewables share of world energy grows to roughly 15% in 2035
- Fossil fuels continue to supply almost 80% of world energy use in 2035
China and India account for about half of the world increase in energy use


Total ozone (DU) / Ozone total (UD), 2011/09/16
Ozone - Polar

- $O_3$

Lowest value of ozone measured each year in the ozone hole. Global average ozone is about 300 Dobson units. Before 1980 ozone less than 200 Dobson units was rarely seen.

There is a lag time between emissions reduction and polar chlorine concentration because it takes some years for the lower atmospheric chlorofluorocarbons to reach the stratosphere and be broken up through action of ultraviolet solar radiation.

The best estimate for the lifetime of CFC-11, for example, is about 50 years.
Montreal Protocol

“Perhaps the single most successful international agreement to date has been the Montreal Protocol.” - Kofi Annan, Former Secretary General of the United Nations

Summary of Montreal Protocol Control Measures

<table>
<thead>
<tr>
<th>Ozone Depleting Substances</th>
<th>Developed Countries</th>
<th>Developing Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorofluorocarbons (CFCs)</td>
<td>Phased out end of 1995 a</td>
<td>Total phase out by 2010</td>
</tr>
<tr>
<td>Halons</td>
<td>Phased out end of 1993</td>
<td>Total phase out by 2010</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>Phased out end of 1995 a</td>
<td>Total phase out by 2015</td>
</tr>
<tr>
<td>Methyl chloroform</td>
<td>Phased out end of 1995 a</td>
<td></td>
</tr>
<tr>
<td>Hydrochlorofluorocarbons (HCFCs)</td>
<td>Freeze from beginning of 1996 b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35% reduction by 2004</td>
<td></td>
</tr>
<tr>
<td></td>
<td>65% reduction by 2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90% reduction by 2015</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total phase out by 2020 c</td>
<td></td>
</tr>
<tr>
<td>Hydrobromofluorocarbons (HBFCs)</td>
<td>Phased out end of 1995</td>
<td></td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>Freeze in 1995 at 1991 base level d</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Freeze in 2002 at average</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25% reduction by 1999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50% reduction by 2001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>70% reduction by 2000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total phase out by 2005</td>
<td></td>
</tr>
</tbody>
</table>

CFC Production and Concentrations

Physics 105 – Fall 2011
Ozone (temperate latitudes)

NASA/NOAA Data
60 degrees North to 60 degrees South

Initial decline of stratospheric chlorine due to Montreal Protocol

First Stage of Ozone Recovery (starting in 1997)

Temporary reduction following Mt. Pinatubo
What lessons have we learned from Ozone?

Cell Phones and Cancer
Do Cell Phones Cause Cancer?

1. Yes
2. No
3. Maybe

Electromagnetic Spectrum

THE ELECTROMAGNETIC SPECTRUM

Penetrates Earth Atmosphere?

Wavelength (meters)

Radio: $10^2$
Microwave: $10^3$
Infrared: $10^4$
Visible: $5 \times 10^4$
Ultraviolet: $10^6$
X-ray: $10^{-12}$
Gamma Ray: $10^{-12}$

About the size of...

Buildings Humans Honey Bee Pinpoint Protozoans Molecules Atoms Atomic Nuclei

Frequency (Hz)

$10^9$
$10^{12}$

Temperature of bodies emitting the wavelength (K)

100 K 10,000 K 10 Million K
Riding downhill to and from the Zoo

The Zoo Region
Do Cell Phones Cause Cancer?

1. Yes
2. No
3. Maybe
Since this is the chance of being outside $n$ sigma, if you are looking for a positive effect the chance is $\frac{1}{2}$ as big.

**Probabilities (2 sided)**

<table>
<thead>
<tr>
<th>$n$</th>
<th>$\text{erf}\left(\frac{n}{\sqrt{2}}\right)$</th>
<th>i.e. 1 minus ...</th>
<th>or 1 in ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.682 689 492 137</td>
<td>0.317 310 507 863</td>
<td>3.151 487 187 53</td>
</tr>
<tr>
<td>2</td>
<td>0.954 499 736 104</td>
<td>0.045 500 263 896</td>
<td>21.977 894 508 0</td>
</tr>
<tr>
<td>3</td>
<td>0.997 300 203 937</td>
<td>0.002 699 796 063</td>
<td>370.398 347 345</td>
</tr>
<tr>
<td>4</td>
<td>0.999 936 657 516</td>
<td>0.000 063 342 484</td>
<td>15,787.192 767 3</td>
</tr>
<tr>
<td>5</td>
<td>0.999 999 426 697</td>
<td>0.000 000 573 303</td>
<td>1,744,277.893 62</td>
</tr>
<tr>
<td>6</td>
<td>0.999 999 998 027</td>
<td>0.000 000 001 973</td>
<td>506,797,345.897</td>
</tr>
</tbody>
</table>

When is it does a result constitute a discovery?
- It varies by field
  - Physics its generally considered “evidence” at 3 sigma ($\sigma$) - (1 chance in 700) and a discovery at 5 sigma (1 chance in 2 million)
  - Often 95% confidence level is just a 2 sigma effect

How often will you exceed $n$ sigma ($\sigma$)?
- Depends on how many independent times you try
- When there are lots of trials the probability goes up of exceeding some value
Michele Bachmann on the HPV Vaccine

- The Republican hopeful said a mother approached her following the debate and told her that her daughter became mentally retarded after receiving the HPV vaccine.
- But the American Academy of Pediatrics blasted Bachmann, saying the notion that the vaccine can cause retardation has “absolutely no scientific validity.”
- She claimed the vaccine was dangerous during the debate with no causality conclusion whatever.
- Besides what does it mean for a 12 or 13 year old to become retarded?
Electricity

Electric Forces

- Matter is composed of particles with charge.
- Charge in electricity plays the role of mass in gravity.
- Unlike mass, charge may be positive or negative
- The unit of charge is the Coulomb.
- Matter is composed of electrons, protons and neutrons.
- Matter is held together via an electric force.
- The proton charge is $e \approx 1.6 \times 10^{-19}$ C.
- The electron charge is exactly $-e$.
- The neutron charge is 0.
- Neutrons are held in the nucleus by another (Nuclear or strong force)

- Opposite charges attract
- Like charges repel
Which force is stronger between an electron and proton – Gravity or Electricity

1. They are both about the same
2. Electricity is a $10^6$ (a million) times strong
3. Gravity is a $10^6$ (a million) times strong
4. Electricity is a $10^{40}$ times stronger
5. Gravity is a $10^{40}$ times stronger
6. It depends on the distance apart

“Electrostatic” Force – Coulomb’s Law

- Two charges, $Q_1$ and $Q_2$, separated by distance $r$ exert a force on each other:
  \[ F = \left( k \cdot Q_1 \cdot Q_2 \right) / r^2 \]
  
- $k$ is a constant ($9 \times 10^9 \text{Nm}^2/\text{C}^2$), $Q$ is in Coulombs, $r$ in meters
  - One unit of charge (proton) has $Q = 1.6 \times 10^{-19} \text{Coulombs}$
  - Looks a lot like Newton’s gravitation in form – $F = (G \cdot m_1 \cdot m_2) / r^2$
  - Electron and proton attract each other $10^{40}$ times stronger electrically than gravitationally!
  - Good thing charge is usually balanced!
Coulomb’s Law - qualitative

- Double one of the charges
  - force doubles
- Change sign of one of the charges
  - force changes direction
- Change sign of both charges
  - force stays the same
- Double the distance between charges
  - force four times weaker
- Double both charges
  - force four times stronger

\[ F = \frac{k \cdot Q_1 \cdot Q_2}{r^2} \]

Charge Balance

- Neutral atoms are made of equal quantities of positive and negative charges
  - Neutral carbon has 6 protons, 6 electrons, (& 6 neutrons)
- Electrons can be stripped off of atoms
  - Electrons occupy the vulnerable outskirts of atoms
- An ion is a particle with non-zero charge
- Usually charge flows in such a way as to maintain neutrality
  - Excess positive charge attracts excess negative charge
  - Your body has \(5 \times 10^{28}\) positive charges and \(5 \times 10^{28}\) negative charges, balanced within millions or billions
Structure of the atom

- neutron
- proton
- electron

“Fly in the cathedral”

Gold atom
- nuclear radius: $7 \times 10^{-15}$ m
- electron orbit radius: $1.3 \times 10^{-10}$ m

Atoms are almost all empty space
Building Blocks

- Protons
- Neutrons
- Electrons

Atoms → Molecules → Solids, liquids, gases

Conductors and Insulators

- In some materials (metals), some electrons get freed from their individual atoms and can move through the material
  - Conductors e.g. Copper, Aluminum, Gold, Silver, Mercury,…

- In most materials, the electrons are bound to their nuclei and cannot freely flow
  - Insulators e.g. rubber, plastics, ceramics, glass, gases
Is water an electrical insulator or conductor

1. Insulator
2. Conductor
3. Neither
**Induced Charge**

- Charge can also be coaxed to redistribute itself within an object.

Result: Attraction!

- Charged rod approaches sphere
- + charge attracted to – charge in rod
- – charge repelled by rod

**The Atom**

A Atom is the smallest form of an element. Atoms combine to form molecules that make up all matter. The term Electricity comes from the Greek word elektron, meaning: Amber. Amber is a fossil resin that Ancients rubbed with wool to produce static electricity. This was their way of “shocking” someone since they had no nylon carpet in their tents!

Hydrogen Atom
Electric Potential

- Separate a positive charge from a negative charge and give it electric potential energy

\[ PE = \text{work} \]

\[ PE = \text{force} \times \text{distance} \]

\[ PE = Eq \times h \]

\[ PE = Eqh \]

To move electric charge against an electric force requires work.

\[ V = \frac{W}{Q} \]

The electric potential energy difference between two points is the work per Coulomb to move charge between the points and is measured in volts where 1 volt = 1 joule/coulomb
**Conductors**

- A conductor is a material (usually a metal such as copper) that allows electric current to pass easily. The current is made up of electrons. This is opposed to an insulator which prevents the flow of electricity through it.
- Charge moves rather freely in good conductors such as copper. A metal wire acts like a pipe for charge.
- In equilibrium, charge distributes itself around the surface such that there is no interior electric field and the entire conductor is at constant potential.

**Basics Circuits**

- **Voltage** is the electrical force, or "pressure", that causes current to flow in a circuit.
  - It is measured in VOLTS (V).
  - Voltage would be the force that is pushing the water (electrons) forward.

- **Current** is the movement of electrical charge
  - the flow of electrons through the electronic circuit. In our analogy, current would be the flow of water moving through the tube (wire).
**Basic Circuits**

- Current direction is from positive to negative voltages.
- Current (I) is the rate charge flows.
  - \( I = \frac{\Delta Q}{\Delta t} \)
- Current is measured in AMPERES (AMPS, A)
  - 1 amp = 1 coulomb / s
- Resistance is anything that causes an opposition to the flow of electricity in a circuit.
- Resistance is used to control the amount of voltage and/or amperage in a circuit. Everything in the circuit causes a resistance (even wire).

**Resistance**

- What happens in a “resistor”?
  - Electrons can’t flow freely
  - They run into atoms and transfers energy to the atoms
  - The resistor heats up
- A light bulb is a resistor
  - It gets so hot it glows

[Image: http://micro.magnet.fsu.edu/electromag/java/filamentresistance/index.html]
What happens when you ski down a hill?

You start with gravitational potential energy and some gets transformed into kinetic energy

\[- V=\sqrt{2gh} \rightarrow h=300m \]
\[- V=78m/s=175mph \]

Assuming you stop at the bottom where did the potential energy go?

Heating and moving the snow

---

**Circuits**

- Lift gain
- Potential
- Ski down
- Drop
- Potential