Homework

1. While scuba diving one day, a depth gauge reports $30.5 \pm 0.5'$. What's the percent uncertainty in the measurement?

2. I catch three fish one day with weights $12 \pm 1lb$, $14 \pm 0.5lb$, and $20 \pm 1lb$. What's the best way to report the weight of my total catch?
   (a) $46 \pm 0.0lb$
   (b) $46 \pm 0.5lb$
   (c) $46 \pm 2lb$
   (d) $46 \pm 5lb$

3. What is the sum of 1.345, 3.444×10^{-1}, and 10.1?

4. What is the product of 3.56×10^3 and 2.41×10^{-1}?

5. The charge of an electron is measured as $1.7 \times 10^{-19}C$. With the proper number of significant digits, what's the percent error?

6. A voltage of $4.0 \pm 0.1V$ is measured with an accompanying $30 \pm 1mA$ current. When the voltage is increased to $8.0 \pm 0.1V$, the current is $62 \pm 2mA$. In units of Ω and with uncertainty calculated, what's the experimental resistance in the circuit? (Answer in the form: _____ $\pm$ ___Ω).

7. I propose a law in which various quantities represented by letters follow the equation:

$$\frac{A\sqrt{B}}{C} = D^3 \ln|E|.$$

   Your experiment to test the law consists of setting B to various values, and measuring A, keeping all else constant. What can you plot on the y-axis if you plot B on the x-axis so that the law predicts a line?

8. What's the most reasonable answer for the uncertainty when reading a regular 'ole mercury thermometer?
   (a) $\pm 0^o F$
   (b) $\pm 0.5^o F$
   (c) $\pm 1^o F$
   (d) $\pm 3^o F$

From: http://www.apc.net/bturner/coils.htm

Tesla Coils

Tesla coils are air-core, resonant transformers. Working at high frequencies, they can generate tremendous voltages with spectacular lightning-like discharges. The most popular use for them has been in the film industry, where they are used whenever lightning or electrical arcs are required. Perhaps the best use of Tesla coil effects can be seen in "The Entity". In this film, the actress actually has lightning bolts radiating from her body, and this scene was not faked. (Bill Wysock provided the effects.) Another film was "Terminator II", specifically the scene where the 'bad' Terminator arrives from the future in the first part of the film. (The scene with all the trucks.). Mark Barton did the Tesla effects.

Pictured above are three Tesla coils that I have built over the years. On the left is a 500-watt vacuum tube powered coil, and it can produce a very hot, 5-6" flaming brush discharge. It operates at 430 KHz. In the middle is a traditional spark-gap coil design. It is powered by a 9,000 volt neon sign transformer, and produces a very nice 14" discharge. The secondary coil is only 14" tall! On the right is a plasma lamp sculpture powered by a solid-state Tesla coil utilizing a flyback transformer. (That's me in the picture.)

Tesla coils are relatively simple, and reasonably easy to construct. Despite the fact that they were invented over 100 years ago, they are still popular and fascinating devices. The problem is the lack of good, solid information.

How They Work

As mentioned, Tesla coils are resonant transformers. This implies that there is a specific frequency at which they operate - the resonant frequency. There is no "special" universal Tesla coil frequency - rather, you either target a frequency in the design, or tune a coil into whatever frequency it happens to be happy with.

What determines this resonant frequency is the secondary coil - a complex LCR network. The inductive (L) component is the physical coil itself, and is based upon the number of turns, the diameter and length of the coil. The capacitive (C) component is comprised of several isotropic values; the surface of the secondary wire and the terminal electrode. (Isotropic capacitance in essence is 'virtual' capacitance - there is a capacitive effect even though it appears like there isn't any physical plates to create the capacitor.) The resistive (R) component consists of the wire itself, and identifies the physical resistance of the secondary coil at the resonant frequency.

To get the secondary to resonate, pulses of energy have to be fed at just the right rate and frequency. A good analogy is that of a bell. To get the bell to ring, you need to tap it with a hammer. If you tap too hard, you can crack the bell. If you tap and hold the hammer on the bell too long, you don't get a clean, pure tone out of the bell.

Energy pulses come from the primary circuit. This circuit is made up of (1) the high-voltage transformer, (2) the primary capacitor, (3) the spark gap and (4) the primary coil. Together, these parts form a crude type of oscillator. What happens is thus: the transformer charges the capacitor up until there is a high enough voltage across the spark gap to jump the air gap. When this spark occurs, the energy stored in the capacitor is 'dumped' into the primary inductor. The primary inductor then builds a magnetic field as the capacitor's energy flows through it. The magnetic field will eventually collapse, and will in turn dump what energy is left back into the capacitor. This see-saw activity continues until there isn't enough voltage left to jump the spark gap.

The oscillation frequency is determined by the value of the primary capacitor and the primary inductor. Together, they form what is called a parallel-resonant circuit. In typical Telsa coil designs, the frequency is adjusted by altering the primary coil's inductance.

If the energy bursts are of the same frequency as the secondary, the energy transferred by the primary's magnetic field will start to build up in the secondary coil. Much like a laser, this energy grows and amplifies itself until there is an incredible voltage built up at the top of the coil, which dissipates into the air in the form of electrical sparks.