PHY 335, Unit 1
Instruments, Signals, Resistors (part 2)

Mini-lecture topics planned:

- **Periodic signals: amplitude, period, frequency; phase**
- **RMS values, decibels, AC power**
- **Voltage divider with the load**
- **Thevenin's equivalents**

1. Explain the theory of a voltage divider (using Ohm's Law): What ratio of resistors R1/R2 is required to make a 1:10 voltage divider? For a 1:5 divider? Achieve 1:10 division to better than 5% (you can either trim the ratio either by plugging in additional resistors or by using a variable resistor (potentiometer). Use precision DVM to measure the voltages.

2. Apply to the voltage divider a signal of known amplitude from the Signal Generator (SG). Measure the amplitude with the scope, and using the scope, see that your divider indeed reduces the amplitude by about a factor of 10. Apply different waveforms and change frequency over a wide range, from Hz to the highest MHz range provided by the SG. Measure output amplitude and frequency using scope; figure out how to measure frequency using a scope.

3. Reset the SG to the same nominal position of the dial several (about 10) times. Each time measure the frequency. Report your result as (mean)±(standard deviation) and the number of measurements made. [N.B.: The uncertainty on the mean is actually given by the standard deviation divided by the square root of the number of samples.]

4. Using the scope's dual-channel capability, measure the phase shift (if any) of the output compared to the input at different frequencies, going to the highest frequency available on the SG. If you find anything of interest, try to qualitatively explain what you see.

5. Root-mean-square values: Using the SG and the scope, set the output amplitude at some value by adjusting the amplitude with the SG and measuring it on the scope. Measure the same output AC voltage using a DMM (one of the digital voltmeters). Compare the two values. Do so for sin, triangle, square waves. Explore a wide frequency range; and comment on the results. In your lab report, derive the ratios you expect in these measurements for different waveforms and compare them to the measured ones.

6. Decibels: Change dB setting (amplitude ranges on the SG (-20) and measure the amplitude changes on the scope. Calculate what they should be (from a definition of dB) and compare. Calculate the ratio of a sinusoidal wave RMS value to its amplitude in decibels.

7. Thevenin's equivalents: Make a simple 1:2 voltage divider with two 10 k resistors, and apply 15 V DC to it (measure actual resistor values and input and output voltage). Calculate V_{th} and R_{th} for this circuit. Experimentally find V_{th} and R_{th} following Thevenin's definitions. Compare calculated and measured values.

8. Attach a load resistor R_L to the output of this divider; first, $R_L \rangle\rangle R_{th}$ (at least 10 times larger), than $R_L \approx R_{th}$ (comparable), than $R_L \approx 0.1\ R_{th}$. Measure the amplitudes of a signal on those loads. Comment, with calculations, on what you see and what you expect theoretically.

9. Take 5 different resistors, connect them all in a random series-parallel arrangement of your choice, taking one output at some point. Apply 15 V DC from the power supply, experimentally find V_{th} and R_{th} (follow the definition of Thevenin's equivalents to find them experimentally). In your report, draw the original circuit and its Thevenin's equivalent circuit. Comment on the value of the load that can be attached to your circuit's output without "bending" the output voltage by more than 10%.