Duke University
Department of Physics

Physics 271 Spring Term 2017

WUN2K FOR LECTURE 7

These are notes summarizing the main concepts you need to understand and be able to apply.

- **Power in AC circuits:** power dissipated is $P(t) = I(t)V(t)$. One cannot use the complex versions of current and voltage directly in this expression (because the physical quantities are real; the use of complex numbers to represent them is predicated on superposition, for linear equations). However the time average of sinusoidal signals is $P_{\text{avg}} = \frac{1}{2}V_0 I_0 \cos\phi$, where ϕ is the phase angle between current and voltage. This can also be written $P_{\text{avg}} = \frac{1}{2}\Re(\hat{V}^*\hat{I}) = \frac{1}{2}\Re(\hat{V}\hat{I}^*)$.
  - The *RMS* (root-mean-square) averaged power is conventionally used for AC circuits: $V_{RMS} = \frac{V_0}{\sqrt{2}}$ and $I_{RMS} = \frac{I_0}{\sqrt{2}}$.
- **Transformers**: these are devices with coils typically wrapped around a core of magnetic material which transform AC voltage amplitudes.
  - The relationship between V_1 and V_2 is $V_2 = \left(\frac{n_2}{n_1}\right)V_1$, where n_1 and n_2 are the number of turns on each side.
  - The current relationship is $I_2 = \left(\frac{n_1}{n_2}\right)I_1$.
  - Transformers are used to "step up" voltages for transmission over long distances (currents are smaller so I^2R losses are smaller), and then step then down for safe use.
  - Transformers are also used for *impedance matching*: a load R_L separated from a sinusoidally driving source by a transformer will "see" an effective load impedance $R_{\text{eff}} = \left(\frac{n_1}{n_2}\right)^2 R_L$. The turn ratio can be chosen for maximum power transmission, which occurs when load impedance equals source output impedance.

- The basic concept of Fourier analysis, very useful for signal processing, is that any real periodic function $f(t)$ can be written as a sum of sinusoidal terms with frequencies that are integer multiples of the fundamental frequency, $\omega_1 = \frac{2\pi}{T}$. We can write $f(t) = \sum_{n=-\infty}^{\infty} \hat{c}_n e^{j\omega_n t}$, where the Fourier coefficients are given by $\hat{c}_n = \frac{1}{T}\int_{t'}^{t'+T} f(t)e^{-j\omega_n t}dt$. A linear transfer function $\hat{H}(j\omega)$ acts on each component of a signal; then one can sum the components to get the transformed signal. In general, a frequency-dependent transfer function will change the *shape* of an input signal.