Final Exam Information
(updated 3:40 pm Dec. 12, 2013)

Rough breakdown of topic coverage:

20-30%	Power factor calculations and power factor correction
20-40%	Real, reactive, and complex power calculations
20-30%	Thévenin and Norton equivalent circuits (DC and AC) and maximum power transfer
10-20%	Sinusoidal steady-state circuit analysis (phasors voltages and currents, equivalent impedances, nodal analysis with phasors)
10-20%	DC nodal analysis
10-20%	Basic op-amp circuits

See the "Course Outcomes" section of the Course Description page at the ELEC 225 web site for a more detailed list of specific competencies that are likely to be assessed.

The exam will take place **8:00-11:00 am on Friday, December 13 in Breakiron 065 (our usual classroom during the semester)**. The exam will be designed to be approximately 1.5 hours in length, but you will have the full three hours to complete it.

You will be allowed to use up to three 8.5 x 11-inch two-sided help sheets. There are no restrictions on the material you may place on the help sheets. Please note that **all help sheets will be collected at the end of the exam** but will be returned to you later if you wish to have them back.

The final exam grade cannot be dropped. Solutions to the final exam will not be posted, but you may review your final exam and discuss it with me after it has been graded.

Review Topics for Final Exam

The following is a list of topics that could appear in one form or another on the exam. Not all of these topics will be covered, and it is possible that an exam problem could cover a detail not specifically listed here. However, this list has been made as comprehensive as possible. You should be familiar with the topics on the previous review sheets in addition to those listed below.

Although every effort has been made to ensure that there are no errors in this review sheet, some might nevertheless appear. The textbook is the final authority in all factual matters, unless errors have been specifically identified there either by the authors (in the form of published errata) or by me. You are ultimately responsible for obtaining accurate information when preparing for your exam.

Sinusoidal steady-state AC circuit analysis using phasors

- complex impedance, Z:
    - general complex impedance: $Z = R + jX$
    - real part (R) is resistance
    - imaginary part (X) is reactance

- reactance (X)
  - o reactance itself is a real quantity; impedance is (in general) complex
  - o example 1: The reactance of a 5-mH inductor at 1000 Hz is 31.4 Ω, but its impedance is j31.4 Ω
  - o example 2: The reactance of a 1-μF capacitor at 1000 Hz is −159 Ω, but its impedance is −j159 Ω.
  - o example 3: Suppose a given complicated arrangement of resistors, inductors, and capacitors has an equivalent impedance of 4120 – j1800 Ω. Its equiv. resistance would be 4120 Ω, and its equiv. reactance would be –1800 Ω.
  - o inductive reactance is positive (impedance of inductor is pos. imaginary)
  - o capacitive reactance is negative (impedance of capacitor is neg. imaginary)
- nodal analysis using phasors
- source transformations using phasors

Resonant circuits

- resonant frequency ω_o of a simple series or parallel LC resonant circuit is given by $$\omega_o^2 = \frac{1}{LC}$$
- series resonance: C and L in series; capacitive reactance equal in magnitude to inductive reactance; equiv. impedance of series combination is zero
- parallel resonance: C and L in parallel; capacitive reactance equal in magnitude to inductive reactance; equiv. impedance of parallel combination is infinity
- voltages can be extremely high in series resonant circuits, even though total voltage across L and C combination is nearly zero
- currents can be extremely high in parallel resonant circuits ("circulating" currents), even though total current flowing into/out of L and C combination is nearly zero

Thévenin and Norton equivalent circuits for AC case (i.e., using phasors)

- use same rules for finding open-ckt voltage and short-ckt current as with DC circuits, but result will be a phasor voltage or current
- need to find equivalent impedance instead of equivalent resistance
- three methods for finding equivalent impedance are conceptually the same as with DC circuits:
  - o $Z_{th} = \mathbf{V}_{oc}/I_{sc}$ (can use only if there are independent sources present)
  - o $Z_{th} = Z_{eq}$ (can use only if there are no dependent sources present)
  - o $Z_{th} = \mathbf{V}_t/I_t$ ("test source" method; can always use)

RMS voltage and current values

- rms = "root mean square" (the square root of the time average, or mean, power over one cycle; voltage is proportional to square root of power)
- for sinusoids, peak and rms magnitude values differ by square root of two factor
- conversion from rms to peak to pp (and back)
- rms value is the "effective" power; used in energy transfer calculations

Power calculations in AC circuits **[this section updated 3:40 pm Dec. 12, 2013]**

- real, or time-average, power (P); unit is the watt (W): $P = \dfrac{V_m I_m}{2}\cos(\phi_v - \phi_i)$,

  where V_m and ϕ_v are the magnitude and phase, respectively, of the voltage, and I_m and ϕ_i are the magnitude and phase, respectively, of the current.
- reactive power (Q); unit is the volt-ampere reactive (VAR): $Q = \dfrac{V_m I_m}{2}\sin(\phi_v - \phi_i)$
- P represents power that either does useful work or is wasted as heat

- Q represents power that is stored and later returned to the source or to other energy-storage devices (capacitors or inductors) in the circuit
- complex power (* indicates complex conjugation):
  - $S = P + jQ$
  - $S = \frac{1}{2}\mathbf{V}\mathbf{I}^*$, if magnitudes of **V** and **I** are expressed as peak values
  - $S = \mathbf{V}_{rms}\mathbf{I}_{rms}^*$, if magnitudes of voltage and current are expressed as rms values
  - $S = \frac{|\mathbf{I}|^2 Z}{2}$ (peak magnitudes) or $S = |\mathbf{I}_{rms}|^2 Z$ (rms magnitudes)
  - $S = \frac{|\mathbf{V}|^2}{2Z^*}$ (peak magnitudes) or $S = \frac{|\mathbf{V}_{rms}|^2}{Z^*}$ (rms magnitudes)
  - apparent power: $|S| = \sqrt{P^2 + Q^2} = \frac{V_m I_m}{2}$
- magnetizing VARs
  - refers to reactive power, Q
  - magnetizing VARs "absorbed" by inductive loads (Q is pos.)
  - magnetizing VARs "delivered" by capacitive loads (Q is neg.)
- power factor (pf)
  - equal to cosine of the power angle (power angle = $\phi_v - \phi_i$)

    pf = $\cos(\phi_v - \phi_i)$, which implies that $\sin(\phi_v - \phi_i) = \pm\sqrt{1 - (\mathrm{pf})^2}$,
    where "+" is used if pf is lagging and "−" is used if pf is leading
  - also equal to cosine of phase of impedance (i.e., $\phi_z = \phi_v - \phi_i$)
  - lagging vs. leading power factor (lagging if i lags v; leading if i leads v)
  - lagging pf indicates an inductive load (pos. reactance); leading pf indicates a capacitive load (neg. reactance)
  - mnemonic: ELI the ICE man
  - pf correction capacitors often added to inductive loads to bring pf to 1 (or closer to 1); "unity" means 1
  - pf correction capacitors are often specified with VAR values, which are understood to apply at a particular voltage rating (VAR value instead of capacitance in farads)

<u>Relevant course material:</u>

HW:	#8
Labs:	#6-#7
Textbook:	Secs. 7-5, 7-6, 7-8, 8-1 through 8-5
Supplements:	"Derivation of Real and Reactive Power Formulas"