WRIGHT STATE UNIVERSITY

**Department of Electrical Engineering Course Syllabus**

**EE 2010/2011** | **Circuit Analysis** | **Fall, 2022**

**Logistics:** 0905 – 1000 (MWF), 005 Student Success Center

**Staff:** Dr. Fred Garber, Russ 312 `fred.garber@wright.edu`

**Office Hours:** TBD, (M,W,F) and anytime (even evenings and weekends) Discord The #ee2010 channel will be monitored throughout the business day.

**Resources:** Recorded lectures, notes, Matlab code, and handouts are available on Pilot.

**References:** Charles K. Alexander and Matthew N.O. Sadiku, *Fundamentals of Electric Circuits*, McGraw-Hill: New York. Any Edition.
John O'Malley, *Schaum's Outline of Basic Circuit Analysis*, $2^{nd}$ edition, 2011 (A great study buddy)
Matlab Symbolic Toolbox. To obtain your copy: Login to `wings.wright.edu` with your campus 'w' username and password. After you're logged in, go to `https://portal.wright.edu/matlab` Follow the instructions on the page to obtain your free MATLAB license

**Grading:** (tentative)

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| Homework ($\sim$ *by module*) | 5% |
| Quizams ($\sim$ 12) | 65% |
| Final | 30% |

**Content Abstract:** We employ *idealized models* for sources and *linearized models* for impedances $R$, $L$, and $C$ and utilize *conservation of charge laws* to produce a *complete system of linear equations* from which a *desired quantity* may be computed.

**Guiding Metaphor:** An andragogical environment characterized by open dialog and team-problem-solving guided by an experiential intuition. Instead of analysis alone leading to a numerical quantity satisfying all constraints, we will, as engineers, conceptualize (at least to first-order) a solution and then validate using our analytical tool set.

**Learning Objectives:** Upon completion of this course, the student should be able to determine any electrical quantity in any lumped, linear, analog circuit driven by any excitation. Enabling concepts for this objective include:

- electrical quantities and their relationships (voltage, current, power, energy)
- voltage-current models of basic circuit elements ($R, C, L$, op-amps, transistors)
- the dynamic behavior of linear, passive energy-storage devices ($C, L$)
- conservation laws (charge and energy) leveraging algebraic solutions, i.e., Kirchoff
- linearity-induced equivalencies and reductions (Thevenin, superposition)
- algebraic models of dynamic systems via transform calculus
- utility of complex models of real-valued quantities at sinusoidal steady state

**Educational Outcomes:** This course exercises the following (ABET):

1. (1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. (6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
3. (7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

**Course Capability Statement:** After successfully completing this course, a student should be able to *characterize any electrical quantity, transient and steady state, at any point, of any lumped, linear electrical circuit that consists of resistors, capacitors, inductors, and amplifiers where these elements are represented by idealized models.* This is the primary outcome driving content design. Corollary course and laboratory outcomes include:

1. Students will be able to employ idealized models for elementary electronic components including sources, resistors, inductors, capacitors, and amplifiers; in time (steady-state and transient), Laplace (steady-state and transient), and Fourier (steady-state) domains.
2. Students will be able to write a complete set of linear equations for any lumped, linear circuit in steady state containing these models as generalized impedances and gains; understanding that "completeness" guarantees the ability to characterize any electrical quantity anywhere in the circuit.
3. Students will be able to employ solvers to characterize any electrical quantity anywhere in the circuit.
4. Students will be able to synthesize these characterizations with the consequences of linearity to derive utilitarian quantities including: transfer functions, equivalent simplified circuits (Thevenin and Norton), and gain/attenuation.
5. Students will be able to compute transient responses of circuits containing dynamic elements.
6. Students will be able to realize and observe representative circuit configurations in a laboratory environment to both validate their (macro) analysis and understand the (micro) anomalous consequences of employing idealized models.
7. Students will be able to use oscilloscopes, meters, power supplies, and function generators to excite and measure circuits in the laboratory.
8. Students will be able to design, realize, observe, and validate circuits that produce certain steady-state and transient behaviors, including (frequency-dependent) gain & attenuation, and responses to common excitation waveforms.

**Quizzes:** Quizzes are closed-book, closed-notes, given (approximately) on a weekly basis. The best $N-1$ out of $N$ quizzes will count as the quiz grade. *No make-up quizzes will be given.*

**Homework:** Homework assignments will be posted. Certain of these problems may be collected and graded. You are strongly encouraged to work all of the assigned homework problems.

**Attendance:** You are responsible for all assignments, changes of assignments, announcements of exam and quiz dates, and other course-related events which occur in class.

| **Circuits in Steady-State: Impedance Analysis** | |
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| Electrical quantities: | Current in Amperes (A) $i(t) = \frac{dq(t)}{dt}$<br>Voltage in Volts (V) $v_{ab}(t) = \frac{dw(t)}{dq(t)}$<br>Power in Watts (W) $p(t) = \frac{dw(t)}{dt} = \frac{dw(t)}{dq(t)} \cdot \frac{dq(t)}{dt} = v(t) \cdot i(t)$<br>Energy in Joules (J) $w(t) = \int p(\tau)dt = \int v(\tau) \cdot i(\tau)dt$<br>Average Power, RMS Power, Power ratios in dB.<br>Algebraic Conventions |
| Models, Active Elements: | Voltage Source (independent and dependent)<br>Current Source (independent and dependent)<br>Topological Combinations |
| Models, Passive Elements: | Resistor (instantaneous) $v(t) = R \cdot i(t)$, $p(t) = v(t) \cdot i(t) = Ri(t)^2 = \frac{v(t)^2}{R}$<br>Passive sign convention<br>Reducible forms: Series and Parallel combinations<br>Capacitor (dynamic) $V(s) = I(s)\frac{1}{Cs}$, $w(t) = \frac{1}{2}Cv(t)^2$<br>Inductor (dynamic) $V(s) = I(s)Ls$, $w(t) = \frac{1}{2}Li(t)^2$ |
| Conservation laws admitting algebraic solutions: | Extracting a complete set of equations from circuit model<br>Self-discovery of KCL, KVL, and Node Techniques<br>Conservation of Charge: Node analysis<br>For $\omega = 0$: Definitions, Conservation of charge, Voltage divider, Current divider<br>Symbolic Computation: Matlab |
| Symbolic Sources & Transfer Functions: | All solutions in Transfer Function form<br>For $\omega = 0$ and $\omega \neq 0$ (sinusoidal): Unified approach using symbolic sources<br>Generalized responses, Superposition |
| Representations for sinusoidal steady-state: | Resistor (instantaneous) $V(\omega) = R \cdot I(\omega)$<br>Capacitor (dynamic) $V(\omega) = I(\omega) \cdot \frac{1}{Cj\omega}$<br>Inductor (dynamic) $V(\omega) = I(\omega) \cdot Lj\omega$<br>For $\omega = 0$ and $\omega \neq 0$ (sinusoidal): Definitions, Conservation of charge, Voltage divider, Current divider<br>Reducible forms: Series and Parallel combinations<br>Single-frequency specialization: Phasor representations<br>Transfer function composite phase: $+j$ tends inductive, $-j$ tends capacitive |

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| Linear Equivalencies & Reductions: | Axioms of *Linearity*: 1 $\Rightarrow$ scaling, 2 $\Rightarrow$ superposition<br>Superposition of transfer functions (DC & AC)<br>Linearity $\Rightarrow$ system load line modeling with 2 points<br>Thevenin (Norton) equivalent reduction<br>Closed-box approach for Thevenin and Norton<br>Accuracy through differences: Wheatstone bridge |
| Operational Amplifiers: | Signal model<br>Ideal simplification assumptions<br>Canonical forms: Inverting, Summing, Difference, etc.<br>Active Filters<br>Cascaded forms |
| **Circuits in Transient: Dynamic Analysis** | |
| $s$-Domain Abstraction: | $N^{th}$ order circuit $s$-domain procedures<br>Impulse, Step & Ramp excitation functions<br>Initial-condition representations |
| $t$-Domain Representations: | Time-domain descriptions: First-order<br>Time-domain descriptions: Second-order |

**Academic Integrity:** Student-teacher relationships are built on trust. For example, students must trust that teachers have made appropriate decisions about the structure and content of the courses that they teach, and teachers must trust that the assignments which students turn in are their own. Acts which undermine this trust undermine the educational process. It is the policy of Wright State University to uphold and support standards of personal honesty and integrity for all students consistent with the goals of a community of scholars and students seeking knowledge and truth. Furthermore, it is the policy of the university to enforce these standards.

The following recommendations are made for students:

1. Be honest at all times.
2. Act fairly towards others. For example, do not seek an unfair advantage over others by cheating with or by looking at other individual's work during examinations or laboratory assignments.
3. Take group as well as individual responsibility for honorable behavior. Collectively, as well as individually, make every effort to prevent and avoid academic misconduct, and reports acts of misconduct that you witness.
4. Know the policy – ignorance is no defense. Read the policy contained in the student handbook. If you have any questions regarding academic misconduct, contact your instructor.

Students are encouraged to get together in small study groups to discuss the course topics and ungraded homework problems. However, students must work on all graded course assignments and examinations on an individual basis.

*What IS allowed:* Students are allowed to discuss the general requirements of assignment to make certain that they understand the problem and its goal. Students are allowed to ask another student (who has completed the assignment) for (brief) help with a syntax error or other minor problem that does not require extensive exploration of the solution. If another student asks you for help AFTER you have finished the assignment, then you may help them briefly, but you may NOT show them your solution. Students may ask a course instructor for more detailed help. If you work with other student in an allowed manner, you are required to acknowledge the collaboration and its extent in the assignment. This will allow the instructor to comment on and correct the degree of collaboration if necessary. Unacknowledged collaboration will be considered dishonest.

*What IS NOT allowed:* Students may NOT collaborate on graded assignments. Students may NOT use material created by other students. You may NOT look at material created by another student until after you have completed the assignment yourself. Students absolutely may NOT turn in someone else's solution with simple cosmetic changes (say, changed variable names) to the solution – this is a gross breach of academic integrity and will result in a failing grade for the course. You are responsible for ensuring that other students do not have access to your work - do not give another student access to your files, do not leave printouts in the recycling bin or printer, do not leave your workstation unattended, etc. If you suspect that your work has been compromised notify your instructor immediately.

*Conduct for Examinations/Quizzes:* The academic code demands that no student should have an unfair advantage over any other student during examinations. Thus, it is strictly forbidden for any student to refer to information from previous offerings of this course unless this information is provided by the instructor to all students fairly. Thus, the use of test banks of previous quizzes or asking questions about examinations or laboratory assignments to prior students is strictly forbidden.

**Recommendations:** Do not skip class. Ask questions in class if you don't understand. Seek help during office hours before it is too late. Work homework problems every day. (Yes, I said every day!) Be ready for quizzes and exams. Before quizzes and exams, study the class notes and examples before you study the text and the homework problems. Work with other students to discuss course material and get help when you are stuck. If you find that you are weak in algebra, calculus, or complex numbers spend time on those topics as soon as possible. Use a tutor if you need one.