EE 2415
Circuit Analysis I

Fall 2018

Dr. Howard T. Russell, Jr.
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Catalog Course Description:

EE 2415 CIRCUIT ANALYSIS I (3-3) Basic circuit concepts of resistor, inductor, and capacitor (RLC) components. Kirchhoff's laws, resistive network analysis, power calculations, loop and node equations, topology, basic network theorems. Dependent sources and operational amplifiers. Computer-assisted solution of circuit problems. Elementary transient time-domain analysis. Introduction to frequency domain analysis and Bode plots. Steady state A-C phasor analysis, including element laws and phasor diagrams. Problems and experimental demonstrations will be covered during recitation and laboratory sessions. Prerequisite: Grade C or better in EE 1106, MATH 2425. Co-requisite: MATH 3319, PHYS 1444.

Topics:

EE 2415 is the first complete course on electric circuit theory and analysis. The course begins with topics on basic electrical engineering quantities and variables and quickly progresses into a review of the fundamental network laws (Ohm's and Kirchhoff's). Following this review is an introduction into voltage and current sources. Resistors and basic resistor networks and operations are covered next. A set of network theorems are developed from the application of the fundamental laws on resistive networks. Matrix methods are applied to the generation and solution of a system of linear network equations (MAME and NAME). The second part of the course begins with the introduction into energy storage elements – the capacitor and the inductor. The behavioral characteristics of the elements in the time-domain are explored with the application of differential equations on the analysis equations. Complete time-domain solutions of first and second order network are developed. The course ends with the application of steady-state concepts on RLC networks, and the development and application of phasors.

Prerequisite:

EE 1106, MATH 2425, co-requisite: MATH 3319, PHYS 1444.

Textbook & Supplements:

1. R.C. Dorf and J.A. Svoboda, *Introduction to Electric Circuits*, *9th Edition*, John Wiley & Sons, Inc., 2014, ISBN 978-1-118-47750-2.
2. EE2415Materials*xx*V2.0 – a series of compressed (zipped) supplemental files made available on blackboard in timely intervals.

Tools:

1. Scientific calculator with matrix operations. Calculators such as the TI-89 Titanium, TI-Nspire™, CX CAS, HP-50G, and Casio FX-CP400-L are recommended. Calculators as components in communication devices are not allowed on exams.
2. PSPICE – found in the Cadence OrCAD 16.6 Lite Software package downloaded free from the Cadence Design Systems, Inc. website (www.cadence.com). Procedure for downloading the package is included in EE2415Materials01V2.0.
3. A good web browser.

Times and Location:

Lecture: **Section 001**, Tuesday and Thursday, 9:30 am to 10:50 am, Wolfe Hall (WH), room 404.
Recitation/Laboratory: **Section 101**, Monday and Wednesday, 8:00 am to 8:50 am, Science Hall (SH), room 105.
Section 102, Monday and Wednesday, 1:00 pm to 1:50 pm, Wolfe Hall (WH), room 221.

Instructor:
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GTAs:
Lecture and recitation lab:
TBD

EE 2415-001 Fall 2018 Lecture Schedule				
Week/Date		**Tuesday**	**Thursday**	**Reading Assignment**
1	8-21/23	No class meeting.	Definition of an electrical network; current and voltage, power and energy, network properties, polarity convention.	Chapter 1 – 1.2 to 1.8 Materials01 & Materials02
2	8-28/30	Resistors – value, tolerance, TCR, power rating; ohm's law; resistor operations – series and parallel combinations.	Voltage and current sources – independent and dependent; opens and shorts, switches, meters, transducers.	Chapter 2 – 2.1 to 2.4
3	9-4/6	Kirchhoff's laws; source operations – combinations, dominance, transformations, shifting, dividers.	Mesh analysis matrix equation (MAME) for resistive networks.	Chapter 2 – 2.5 to 2.11 Chapter 3 – 3.1 to 3.6 Materials02
4	9-11/13	MAME examples and applications.	Node analysis matrix equation (NAME) for resistive networks.	Chapter 4 – 4.5 to 4.7 Materials03
5	9-18/20	NAME examples and applications.	Equivalences – Thevenin's and Norton's theorems, superposition, substitution, maximum power transfer.	Chapter 4 – 4.1 to 4.4 Materials03
6	9-25/27	**Mid-Term Exam 1**	Energy storage elements, capacitors, energy stored in capacitors, series and parallel capacitors.	Chapter 5 – 5.1 to 5.6 Materials04
7	10-2/4	Inductors, energy stored in inductors, series and parallel inductors.	Phasors – phasor relationships for RLC elements.	Chapter 7 – 7.1 to 7.7
8	10-9/11	Sinusoidal steady-state network response with sinusoidal excitation.	Complex impedance and admittance; Kirchhoff's laws.	Chapter 10 – 10.1 to 10.3 Materials05
9	10-16/18	MAME and NAME using phasors.	Initial and final time-domain conditions in switched RC and RL networks.	Chapter 10 – 10.4 to 10.10
10	10-23/25	First-order RC and RL networks, generation and solution of 1st order ODE with constant excitations.	Generation and solution of 1st order ODE with sinusoidal excitations.	Chapter 8 – 8.1 to 8.4 Materials06
11	10-30/ 11-1	**Mid-Term Exam 2**	Time constants, rise and fall times, sequential switching, differential operators (DO).	Chapter 8 – 8.5 to 8.8 Chapter 9 – 9.1 to 9.3

12	11-6/8	Networks with two energy storage elements, DO generation and solution of 2nd order homogenous ODE.	Natural response characteristics, underdamped, critically damped, overdamped, oscillatory.	Chapter 9 – 9.4 to 9.8 Materials07
13	11-13/15	Complete solution of a 2nd order RLC network with constant excitation.	Complete solution of a 2nd order RLC network with sinusoidal excitation.	Chapter 10 – 10.11
14	11-20/22	The operational amplifier (op-amp), ideal and non-ideal op-amps.	Op-amps in feedback networks; loop gain, gain error, noise gain, stability.	Chapter 6 – 6.1 to 6.7 Materials08
15	11-27/29	The frequency domain, frequency response characteristics of linear networks.	Network response functions, immittance and transfer functions; frequency response plots, Bode plots.	Chapter 13 – 13.1 to 13.4
16	12-4/6	Electric power, instantaneous, average, and complex power.	Power factor, power factor correction; maximum power transfer.	Chapter 11 – 11.1 to 11.8
17	12-11/13	**Final Exam** **8:00 am to 10:30 am**		

Lecture Topic Details:

1. Review of algebra and linear algebra concepts
2. Fundamentals
    a. Quantities and variables
        1. Electron energy and charge
        2. Voltage and current
        3. Energy and power
        4. Polarities and units
    b. Network properties and definitions
        1. Definition of a mathematical model
        2. Linearity versus non-linearity
            i. First-order linearization method
            ii. High-order linearization method
        3. Large signal versus small signal properties
        4. Passive versus active devices
        5. LLFTI properties
    c. Laws
        1. Voltage-current relationship (Ohm's law)
        2. Conservation of charge transfer (Kirchhoff's current law KCL)
        3. Continuity of voltage (Kirchhoff's voltage law KVL)
3. Voltage and current sources
    a. Independent sources
        1. Voltage sources
            i. Types and symbols
            ii. IV characteristics
            iii. Batteries
        2. Current sources
            i. Types and symbols
            ii. IV characteristics
    b. Dependent (controlled) sources
        1. Voltage sources
            i. VCVS
            ii. CCVS
        2. Current sources
            i. VCCS

ii. CCCS

4. Resistors and simple resistor networks
   a. Resistance and conductance; construction, symbol, units
   b. Series connection
      1. Voltage divider
   c. Parallel connection
      1. Current divider
5. Network theorems I
   a. Source dominance
   b. Source combinations
   c. Source shifting
      1. e-shift operation
      2. i-shift operation
   d. Source transformations
      1. Voltage to current
      2. Current to voltage
6 Network theorems II
   a. Thevenin's theorem
   b. Norton's theorem
   c. Substitution
   d. Superposition
7. Application of network theorems to simple networks
   a. Reduction operations
   b. Elimination operation
   c. Equivalence operations
8. Vectors and matrices
   a. Definitions
   b. Mathematical operations
   c. Special matrices
   d. Matrix inverse
   e. Rank and equivalence
9. System of linear equations
   a. Dependence and independence
   b. Solutions of systems of simultaneous linear equations
10. Obtaining the system of network mesh-analysis equations
   a. Direct application of KVL, KCL, and Ohm's law
   b. Expressing the equations in vector-matrix format
11. Obtaining the system of network node-analysis equations
   a. Direct application of KVL, KCL, and Ohm's law
   b. Expressing the equations in vector-matrix format
12. Algorithms for generating matrix analysis equations
   a. Mesh-analysis matrix equation (MAME)
   b. Node-analysis matrix equation (NAME)
13. Energy storage components
   a. The capacitor
      1. Construction and symbol
      2. Charge-voltage (CV) relationship
      3. Current-voltage (IV) relationship
      4. Definition of capacitance
      5. Energy storage capacity
   b. The inductor
      1. Construction and symbol
      2. Flux linkage-current (λI) relationship
      3. Current-voltage (IV) relationship
      4. Definition of inductance
      5. Energy storage capacity

References:

1. Thomas L. Floyd, *Electric Circuits Fundamentals, 7th Edition*, Pearson Prentice Hall, Upper Saddle River, NJ, 2007, ISBN 0-13-219710-3
2. Robert T. Paynter and B.J. Toby Boydell, *Electronics Technology Fundamentals: Electron Flow Version*, Pearson Prentice Hall, Upper Saddle River, NJ, 2009, ISBN 0-13-501345-3
3. Allan R. Hambley, *Electrical Engineering: Principles and Applications, 3rd Edition*, Pearson Prentice Hall, Upper Saddle River, NJ, 2005, ISBN 0-13-147046-9
4. J. David Irwin and R. Mark Nelms, *Basic Engineering Circuit Analysis, 8th Edition*, John Wiley & Sons, Inc., 2005, ISBN 0-471-48728-7

Student Learning Outcomes:

EE 2415
Course Learning Objectives
and Assessment Approach

Number	Course Learning Objective (CLO)	ABET Outcome	Assessment Approach
1	An understanding of dependent sources and their application in generating device models.	a, e	exam problems
2	An ability to mathematically formulate multiple mesh and node analysis matrix equations for linear networks with and without dependent sources.	a, e	exam problems
3	An understanding of network theorems such as superposition, Thevenin's and Norton's theorem, and maximum power transfer.	a, e	exam problems
4	An understanding of energy storage elements such as capacitors and inductors, voltage and current relationships, and energy storage.	a, e	exam problems
5	An understanding of first-order RC and RL circuits, constant input, sequential switching, non-constant input, differential operators.	a, c, e	exam problems
6	An understanding of circuits with two energy storage elements, 2nd order differential equations, natural, forced, and complete response of a critically-damped parallel RLC circuit.	a, e	exam problems
7	An understanding of steady-state response of an RLC circuit to a sinusoidal excitation, complex exponential forcing function.	a, e	exam problems
8	An understanding of phasors, phasor relationships for RLC elements, impedance and admittance, Kirchhoff's laws using phasors.	a, e	exam problems
9	The application of computer tools and software in the solution of circuit design problems.	a, k	lab experiments
10	An ability to use conventional electrical engineering instruments and equipment.	a, e, k	lab experiments
11	A working understanding of important analytical principles.	a, b, c	lab experiments
12	An ability to work as a member of a team.	d	lab experiments

13	An ability to understand and resolve professional ethical issues.	f	lab experiments

Outcomes a-k
(a-k as listed by ABET)

a. an ability to apply knowledge of mathematics, science, and engineering;
b. an ability to design and construct experiments, as well as to analyze and interpret data;
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d. an ability to function on multidisciplinary teams;
e. an ability to identify, formulate, and solve engineering problems;
f. an understanding of professional and ethical responsibility;
g. an ability to communicate effectively;
h. the broad education necessary to understand the impact of engineering solutions in a global and societal context;
i. a recognition of the need for, and an ability to engage in lifelong learning;
j. a knowledge of contemporary issues;
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

General Class Information:

1. There are 32 class meetings scheduled for the 17 weeks of the Fall 2018 Semester. Twenty-eight of these meetings are devoted to in-class lectures while three are reserved for examinations (two mid-terms and one final) and one for the Thanksgiving holiday.
2. Your 100% attendance in lectures and labs is mandatory and required. This requirement will not be waived for any reason.
3. There will be five to six homework assignments usually given on two-week intervals. Each assignment requires about five to ten hours for completion. These assignments will be graded and will be included as part of your total course grade. Experience has shown that students who spend the necessary time to work these assignments usually do quite well on the examinations. Solutions to homework problems will be placed on blackboard for all students by the end of the day the assignment is due. Homework turned in after the solutions have placed on blackboard will not be counted and will receive a grade of zero.
4. Mid-term examinations will be given on the 7^{th} and 11^{th} weeks and will be 1.5 hour written exercises.
5. The final examination will be given on **Tuesday, December 11, 2018** and will be a comprehensive written examination. **NOTICE**: The UTA registrar has demanded a firm, unforgivable final date (four calendar days after the last final examination date) for the submission of course grades from all instructors. Because of this rigid schedule, the date scheduled for the final examination (**Tuesday, December 11, 2018, 8:00 am to 10:30 am**) is fixed and will not be changed for any reason. Therefore, all students, without exception, **must** take the final examination at this time.
6. You are respectively requested to turn off all electronic devices (including but not limited to cell phones of any type, desktop computers, laptop computers, iPads, tablets, towers, and any device capable of communication inside or outside the classroom) while in the Lecture/Lab Sections. Communication devices of any type are not allowed to be used on all exams. No exceptions. Calculators without communication capability are permitted.
7. All examinations will be pencil, paper, and calculator exercises. All students will take these exams at the scheduled times in the classroom.
8. There will be no late or make-up mid-term examinations given unless a written request has been submitted to and approved by the instructor at least two weeks prior to the examination date. As a rule, make-up examinations are several orders of magnitude more difficult than examinations given on the scheduled dates. Please be advised that illness or any other absence on the examination date does not constitute a valid reason for a make-up examination.
9. **NOTICE**: A total score of '0' on any exam (MTE1, MTE2, and/or FE) will automatically result in a course letter grade of 'F'. This includes the failure to take any of the given exams scheduled or approved make-up. You are required to take all exams.
10. The *total grade* (T) for this course is based upon homework, recitation lab, two mid-term exams, and final exam grades. The total T is computed from

$$T = 0.1 \cdot (HW + RA) + 0.25 \cdot (MTE1 + MTE2) + 0.3 \cdot FE \quad (1)$$

HW = homework average
RA = recitation grade
MTE1 = mid-term exam 1 grade
MTE2 = mid-term exam 2 grade
FE = final exam grade

The letter grade is based on the range of the total grade shown below.

Percentage for Grades	
Total grade (T) range	Letter grade
87% - 100%	A
74% - 86%	B
62% - 73%	C
50% - 61%	D
0% - 49%	F

11. Office hours are posted outside my office (NH526). If you have any questions and/or adverse difficulty with the lectures or class material, I strongly suggest that you call or e-mail me (during regular working hours, of course). If necessary, a scheduled office visit can be arranged.
12. Additional important dates:
    End of late registration: – **Monday, August 27, 2018**.
    Census date – **Friday, September 7, 2018**.
    Last day to drop classes – **Friday, November 2, 2018.**
    Spring 2019 registration begins – **Friday, November 9, 2018**.
    Thanksgiving Holidays – **Wednesday, November 21, 2018 to Friday, November 23, 2018**.
    Last day of classes – **Tuesday, December 4, 2018**.
    Final Exam date – **Tuesday, December 11, 2018**

Drop Policy:

Please refer to the University policy for dropping courses.

Americans With Disabilities Act:

The University of Texas at Arlington is on record as being committed to both the spirit and letter of federal equal opportunity legislation; reference Public Law 92-112 - The Rehabilitation Act of 1973 as amended. With the passage of federal legislation entitled *Americans with Disabilities Act (ADA)*, pursuant to section 504 of the Rehabilitation Act, there is renewed focus on providing this population with the same opportunities enjoyed by all citizens. As a faculty member, I am required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of that disability. Student responsibility primarily rests with informing faculty of their need for accommodation and in providing authorized documentation through designated administrative channels. Information regarding specific diagnostic criteria and policies for obtaining academic accommodations can be found at www.uta.edu/disability. Also, you may visit the Office for Students with Disabilities in room 102 of University Hall or call them at (817) 272-3364.

Student Support Services Available:

The University of Texas at Arlington supports a variety of student success programs to help you connect with the University and achieve academic success. These programs include learning assistance, developmental education, advising and mentoring, admission and transition, and federally funded programs. Students requiring assistance academically, personally, or socially should contact the Office of Student Success Programs at 817-272-6107 for more information and appropriate referrals.

Final Review Week:

A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week unless specified in the class syllabi. During Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. Classes are held as scheduled during this week and lectures and presentations may be given.

E-Culture Policy:

The University of Texas at Arlington has adopted the University email address as an official means of communication with students. Through the use of email, UT-Arlington is able to provide students with relevant and timely information, designed to facilitate student success. In particular, important information concerning registration, financial aid, payment of bills, and graduation may be sent to students through email. All students are assigned an email account and information about activating and using it is available at www.uta.edu/email. New students (first semester at UTA) are able to activate their email account 24 hours after registering for courses. There is no additional charge to students for using this account, and it remains active as long as a student is enrolled at UT-Arlington. Students are responsible for checking their email regularly.

Ethics:

Student Responsibility

Undergraduate and graduate students assume full responsibility for knowledge of all University rules, regulations and deadlines published in the Undergraduate and Graduate Catalogs and of all departmental and program requirements concerning their degree programs.

Academic Dishonesty

All students are expected to pursue their academic careers with honesty and integrity. Academic dishonesty includes, but is not limited to, cheating on a test or other coursework, plagiarism (offering the work of another as one's own) and unauthorized collaboration with another person. Students found responsible for dishonesty in their academic pursuits are subject to penalties that may range from disciplinary probation, suspension or expulsion from the University. In accordance with the Rules and Regulations of the Board of Regents of The University of Texas System (Part One, Chapter VI), institutional procedures regarding allegations of academic dishonesty are outlined in Part Two, Chapter 2, of the U.T. Arlington Handbook of Operating Procedures. This information may be obtained by accessing the Dean of Students' Web site at www.uta.edu/studentaffairs/dos or the Student Judicial Affairs' Web site at www.uta.edu/studentaffairs/judicial affairs. Copies of each regulation can be obtained in the Dean of Students' Office on the lower level of the University Center.

Definitions (UTA Handbook of Operating Procedures)

F. scholastic dishonesty, including, but not limited to, cheating on an examination or an assignment, plagiarism, and collusion;

1. *cheating on an examination or an assignment* includes:
   a. copying the work of another, engaging in written, oral or any other means of communication with another, or giving aid to or seeking aid from another when not permitted by the instructor;
   b. using material during an examination or when completing an assignment that is not authorized by the person giving the examination or making the work assignment;
   c. taking or attempting to take an examination for another, or allowing another to take or attempt to take an examination for a student;
   d. using, obtaining, or attempting to obtain by any means, the whole or any part of an un-administered examination or work assignment;
   e. any act designed to give unfair advantage to a student or the attempt to commit such an act;
2. *plagiarism* means the unacknowledged incorporation of the work of another in work that is offered for credit;
3. *collusion* means the unauthorized collaboration with another in preparing work that is offered for credit.

The following is an excerpt from the College of Engineering's statement on Ethics, Professionalism, and Conduct of Engineering Students. Read the statement carefully, sign it, and return it to your instructor. You may make a copy for your records. Additional copies of this statement can be obtained from your instructor or the Office of the Dean of Engineering.

STATEMENT ON ETHICS, PROFESSIONALISM, AND CONDUCT FOR ENGINEERING STUDENTS

COLLEGE OF ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

The College cannot and will not tolerate any form of academic dishonesty by its students. This includes, but is not limited to cheating on examination, plagiarism, or collusion.

Cheating on an examination includes:

1. Copying from another's paper, any means of communication with another during examination, giving aid to or receiving aid from another during examination;
2. Using any material during examination that is unauthorized by the proctor;
3. Taking or attempting to take an examination for another student or allowing another student to take or attempt to take an examination for oneself.
4. Using, obtaining, or attempting to obtain by any means the whole or any part of an un-administered examination.

Plagiarism is the unacknowledged incorporation of another's work into work which the student offers for credit.
Collusion is the unauthorized collaboration of another in preparing work that a student offers for credit.

I have read and I understand the above statement.

In addition, I understand that, in order to ensure fairness to all students, exams will be proctored and possibly videotaped.

Course and section number: ____EE 2415-001/101/102_____

Date: _____

Student's signature: _____

Student's name, printed: _____

Student's ID number: _____

Student's e-mail address: _____
(please print clearly)

Detach this page and return it to the instructor or GTA.