

ECE2280

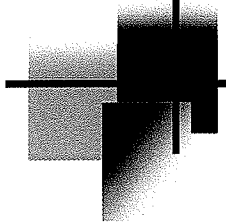
Fundamentals of Engineering Electronics

Professor Angela Rasmussen



Course Structure

- Lecture
- Homework – drop lowest score (NO LATE!)
- Quiz – drop lowest score (NO MAKEUPS)
- PSpice Projects (3)
- Exams (3), Final(Content from each Exam)
- Labs
 - 5 Labs/3 projects



Course Grading

Homework – 9% (low dropped)

Quizzes – 7% (low dropped)

Spice – 9%

Labs – 15%

3 Exams – 60%



Class Web Page

- Class Web Page:
 - <http://www.ece.utah.edu/~ece2280>
- Email:
 - ece2280@comcast.net

UNIVERSITY OF UTAH
Department of Electrical and Computer Engineering
ECE 2280 Fundamentals of Engineering Electronics
Syllabus

Prerequisites: MATH 2250, PHYCS 2220, and ECE 2270

Lecturer: Professor Angela Rasmussen
Office: MEB 3254
Phone: 971-1096
Email: ece2280@comcast.net

office hrs: M, W
9:45-11:15
or arrangement

Website: <http://www.ece.utah.edu/~ece2280>

Textbook: Sedra and Smith, *Microelectronic Circuits*, 6th edition

Course Objectives:

- Understanding of signals and frequencies (Bode Plots)
- Characteristics, analysis, and design using operational amplifiers
- Characteristics of diodes, BJTs, and FETs
- Analysis and design of diodes, BJTs, FETs in electronic circuits
- Efficient at using PSPICE
- Become a better problem solver

Lecture: It is essential that you attend the lecture and take complete and accurate notes. Not all material given in lecture will necessarily be from the text. You are responsible for all topics, discussions, handouts and announcements made in class.

put in Homework Locker

Homework: Assignment due dates are noted in the tentative schedule and due in the lockers located on the 3rd floor of the MEB by 5pm on the day noted. **No late assignments will be accepted.** However, your lowest homework grade will be dropped. If you plan on being absent on a day that a homework set is due, you may either turn it in earlier or have a friend turn it in for you. **Homework will not be accepted late.**

Although collaboration with fellow students on homework assignments and studying is encouraged, you will benefit most from the homework if you attempt to do the problems before consulting with your friends. While it is perfectly reasonable to discuss your approach to solving the problems with a friend, the final write-up of the solution must be your own work. Copying or allowing another student to copy your work is considered cheating.

Homework will be your main study guide. Therefore, think of it as preparation for each exam. Please write clearly, show all of your work in an organized manner, put problems in the proper order and staple each homework set. Make sure you understand all of the homework.

The homework problems will be graded only for correct answers and basic approach. A homework solution displaying both a correct approach and correct answer will receive 1.5 points. The correct approach is worth 1.0 points, and the correct answer will receive 0.5 points. Detailed grading will be left to the student. Solutions to the homework will be posted on the course website soon after the homework is due.

Weekly Quiz: Almost every Wednesday at the beginning of class, there will be a quiz. The quiz will cover material from class, lab, and homework. **No make-up quizzes will be given.** However, your lowest quiz score will be dropped. Open book/notes.

SPICE Projects: Three computer simulation problems will be assigned during the semester. One letter grade (10% off grade) will be dropped per day late or per weekend that the completed project is late. After 5 days, the completed project will be given 25 points.

Exams: Three exams and a final will be given as noted on the class schedule. Exams will be **closed notes and book**. You will be allowed 1 sheet (8 ½ by 11) front and back of handwritten notes for each exam. The final will be broken into 3 parts. The final is optional. If the final is not taken, the midterm exam scores will be used to calculate the final grade. If the final is taken, that exam will be used to calculate the final grade. The first part corresponds to the material of the first exam. The second part corresponds to the material of the second exam and similarly for the third part of the final. You will be allowed 1 sheet for the each part of the final. In NO CASE will make-up exams be given unless the student obtained approval from the instructor PRIOR to the time of the exam. In emergency situations, students will be expected to produce a doctor's certificate indicating the nature and time of the medical emergency.

Labs: Lab will be held every week. Many of the subjects covered in lab aren't covered anywhere else in class, so make sure you pay attention and read the lab handouts. You will have to keep a laboratory notebook as a requirement of the lab. Your lab TA will grade these notebooks.

Labs are **not optional**. For each lab that you miss or fail your final grade will suffer a **half letter drop** (5% of possible points). Be sure to make-up any labs you miss or fail by making arrangements with your TA.

Grading: Your final grade will be determined based on the homework, weekly quizzes, spice assignments, midterms, and final exam. Your lowest weekly quiz grade and your lowest homework grade will be dropped. Your grade will be calculated with the following distribution:

1st:

Homework – 9% (lowest score dropped)

Quizzes – 7% (lowest score dropped)

Spice – 9%

Lab (experiments/projects) – 15%

3 Exams – 60%

Grades: Your score will determine your grade as follows:

A+	97 - 100
A	94 - 96
A-	90 - 94
B+	87 - 90

B	83 - 87
B-	80 - 83
C+	77 - 80

C	73 - 77
C-	70 - 73
D+	67 - 70

D	63 - 67
D-	60 - 63
F	<60

Each student must do his/her own work. Copying from other students or allowing other students to copy on homework, quizzes, SPICE assignments, or exams is cheating. It is not tolerated and will result in a grade of "0" for the assignment/exam and possibly an automatic "F" for the course and may be referred to the University Judicial Procedures office. If you observe cheating at any time, please come and talk to me or the proctor about it.

Americans with Disabilities Act Information:

The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in this class, reasonable prior notice needs to be given to the instructor and to the Center for Disability Services, 162 Olpin Union Building, 581-5020 (V/TDD) to make arrangements for accommodations.

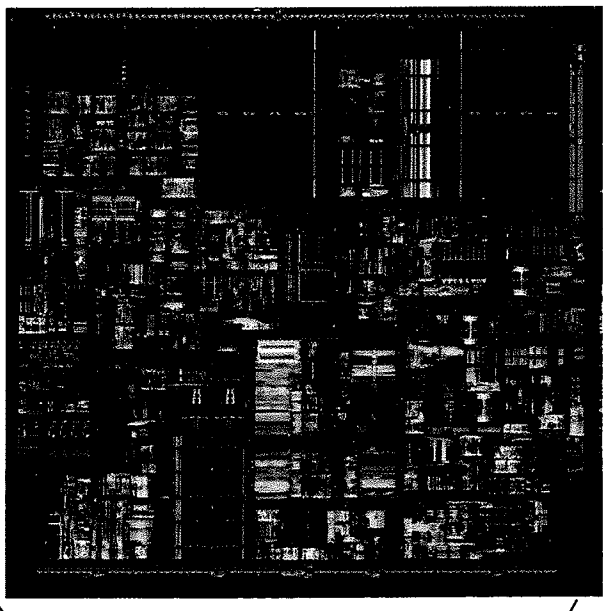
**ECE 2280 –Spring 2012
Tentative Class Schedule**

<i>Week</i>		<i>Date</i>	<i>Topic</i>	<i>Lab</i>	<i>Text (Read before class)</i>
1	M	Jan. 9	Introduction, Review		
	W	Jan. 11	Bode Plots, PSPICE		Appendix F, notes, Sec. 1.1-1.3
	F	Jan. 13		Pre Lab (Lab 1)	
2	M	Jan. 16	Martin Luther King Day		
	W	Jan. 18	Bode Plots, PSpice		
	F	Jan. 20	HW #1 due		
3	M	Jan. 23	Ideal Amplifiers	(Lab 2)	Sec. 1.4-1.6, 2.1-2.4
	W	Jan. 25	Non-ideal amplifiers Quiz 1		Sec. 2.6-2.8
	F	Jan. 27	HW #2 due		
4	M	Jan. 30	Diodes, AC Analysis, Physics	(Lab 2/3)	Sec. 4.1-4.7
	W	Feb. 1	Diodes Quiz 2		
	F	Feb. 3	HW#3 due		
5	M	Feb. 6	Review		
	W	Feb. 8	Midterm #1		Ch. 1,2,4, Bode Plots
	F	Feb. 10		SPICE #1 (put in homework locker)	
6	M	Feb. 13	MOSFET Introduction, DC Analysis		Sec. 5.1-5.3
	W	Feb. 15	MOSFET Analysis		
	F	Feb. 17	HW #4 due	Project #1 Pre Lab (Lab 4)	
7	M	Feb. 20	<i>President's Day</i>		
	W	Feb. 22	MOSFET Amplifiers Quiz 3		Sec. 5.4-5.9
	F	Feb. 24	HW #5 due	Lab 4	
8	M	Feb. 27	MOSFET Amplifier Analysis		
	W	Feb. 29	MOSFET Quiz 4		
	F	March 2	HW #6 due		
9	M	March 5	Review		
	W	Feb. 8	Midterm #2		Ch. 5
	F	March 9		SPICE #2 (put in homework locker)	
10	M	March 12-17	<i>Spring Break</i>		
11	M	March 19	BJT Introduction, DC Analysis		Sec. 6.1-6.3
	W	March 21	BJT Analysis		
	F	March 23	HW #7 due	Project #2 Pre Lab (Lab 5)	
12	M	March 26	BJT Analysis	Lab 5	Sec. 6.4-6.9
	W	March 28	BJT Analysis Quiz 5		
	F	March 30	HW #8 due		
13	M	April 2	BJT Analysis		
	W	April 4	BJT Analysis Quiz 6		
	F	April 6	HW#9 due		
14	M	April 9	BJT Amplifiers		
	W	April 11	BJT Amplifiers Quiz 7		
	F	April 13	HW#10 due	SPICE #3 (put in homework locker)	
15	M	April 16	Review		
	W	April 18	Review		
	F	April 20			
16	M	April 23	Midterm #3		Chapter 6
	W	April 25	Comprehensive Review		LAST DAY OF CLASS
		April 27	Final Exam, 8-11am Part 1 8-9 Part 2 9-10 Part 3 10-11	Project #3 due by 4/27	Comprehensive

What is Microelectronics?

Definition: The technology and techniques involved in the design, development, and construction of extremely small electronic circuits (for example, computers on a single silicon chip) (MS Encarta)

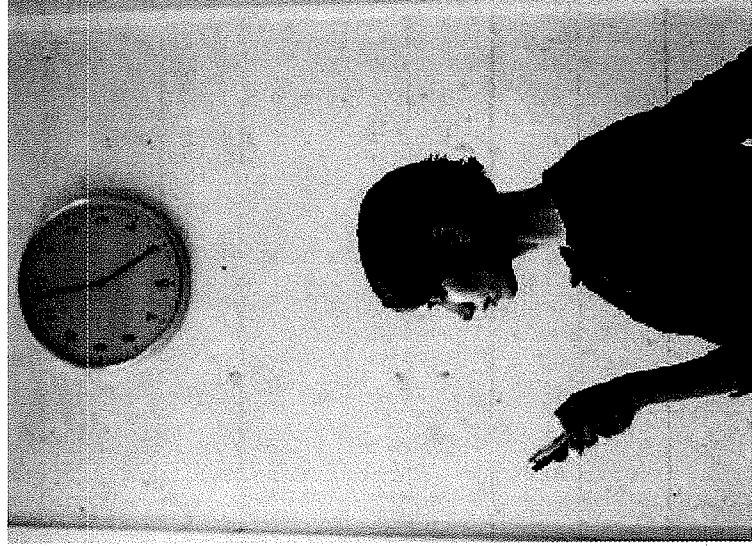
Microelectronics ~ integrated-circuit (IC) technology
(we will study what is inside an IC)



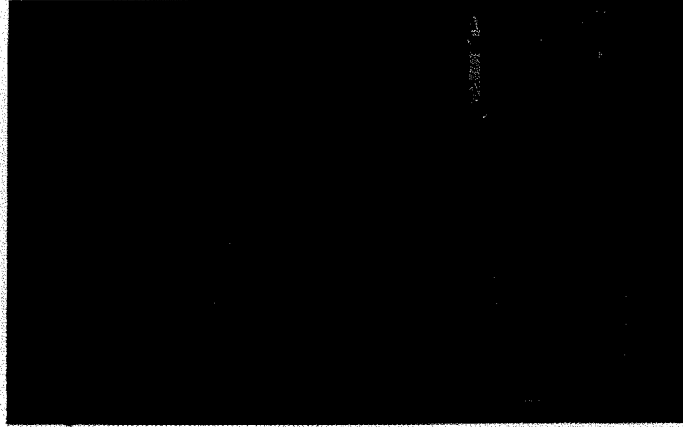
What is Microelectronics?

→ Currently capable of producing circuits that contain millions of components in a piece of silicon on the order of 1cm². (S&S)

To put this in perspective, every time you make a phone call or send an e-mail message, you are using several billion transistors in worldwide communications networks (MS Encarta)



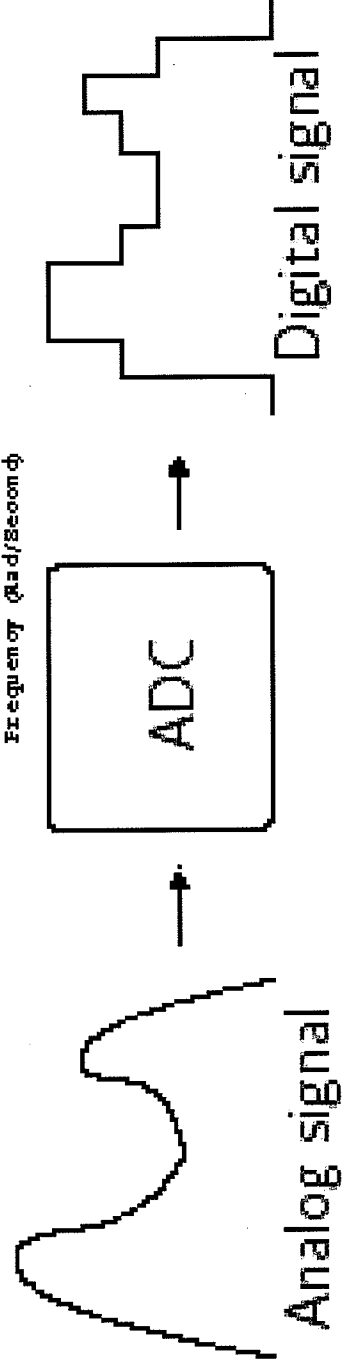
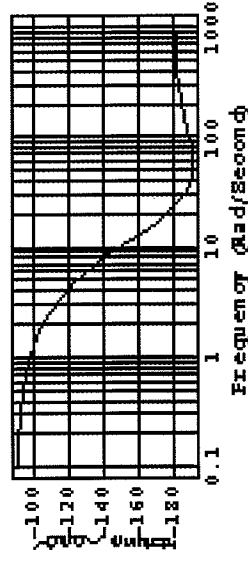
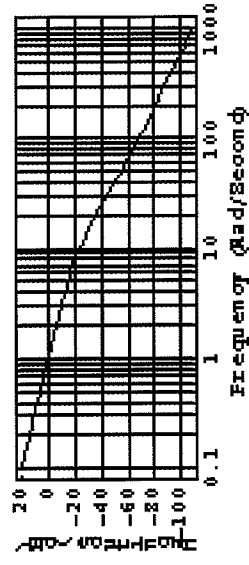
I486™ MICROPROCESSOR
1.2 MILLION TRANSISTORS



The I486 microprocessor packs 1,200,000 transistors into a 217 x 209 mil. Packaging a high-level of integration. An I486 CPU has complex, 5 transistors per bit, 64 cache and memory management unit paths.

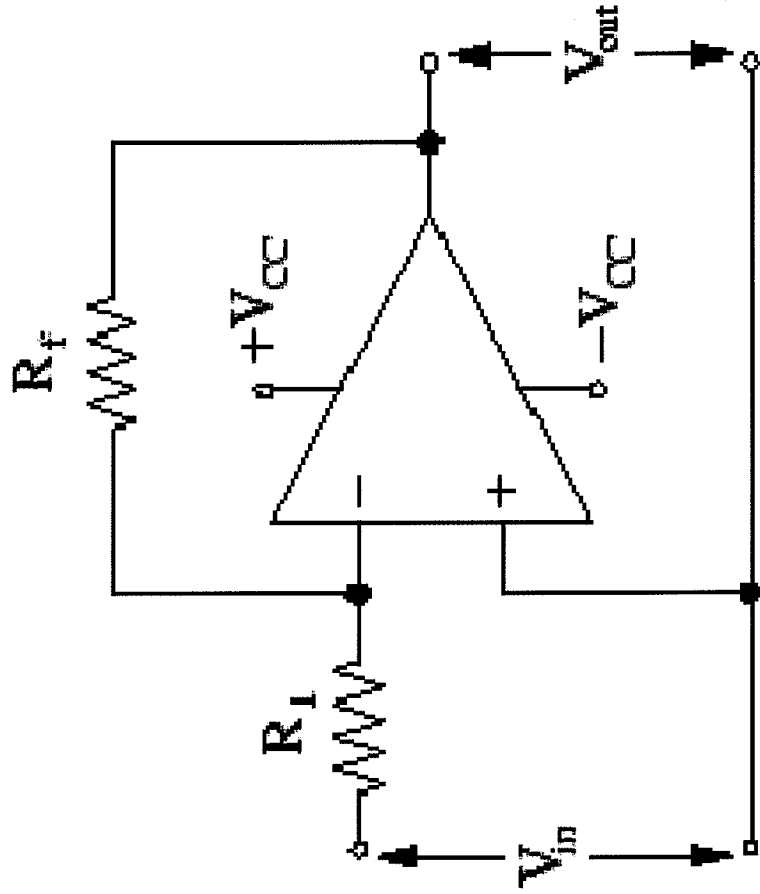
What you will learn

- Understanding of signals and frequencies (Bode Plots)



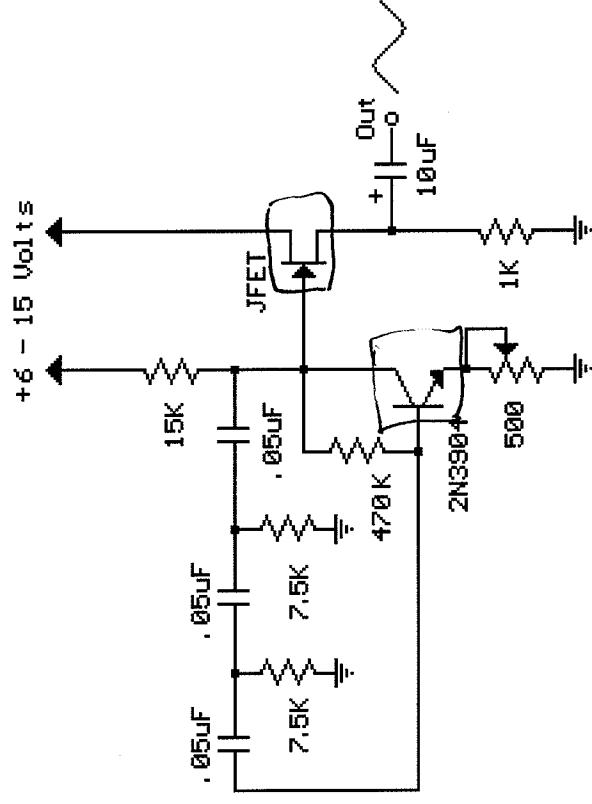
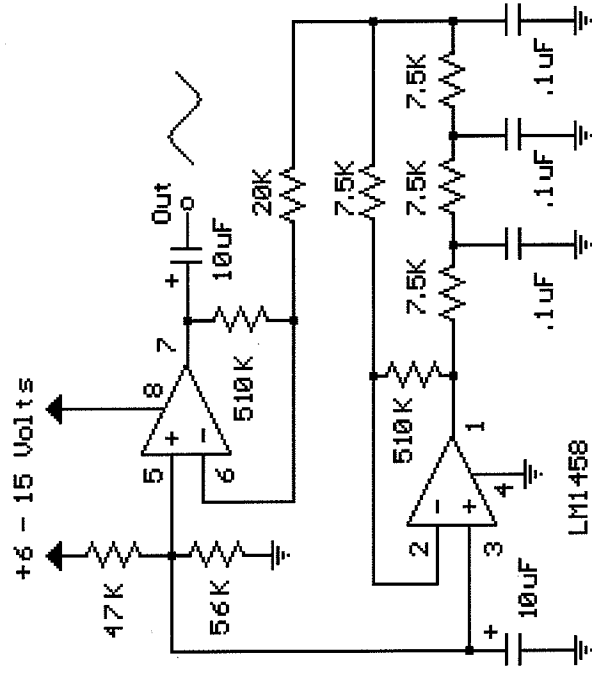
What you will learn

- Characteristics of operational amplifiers



What you will learn

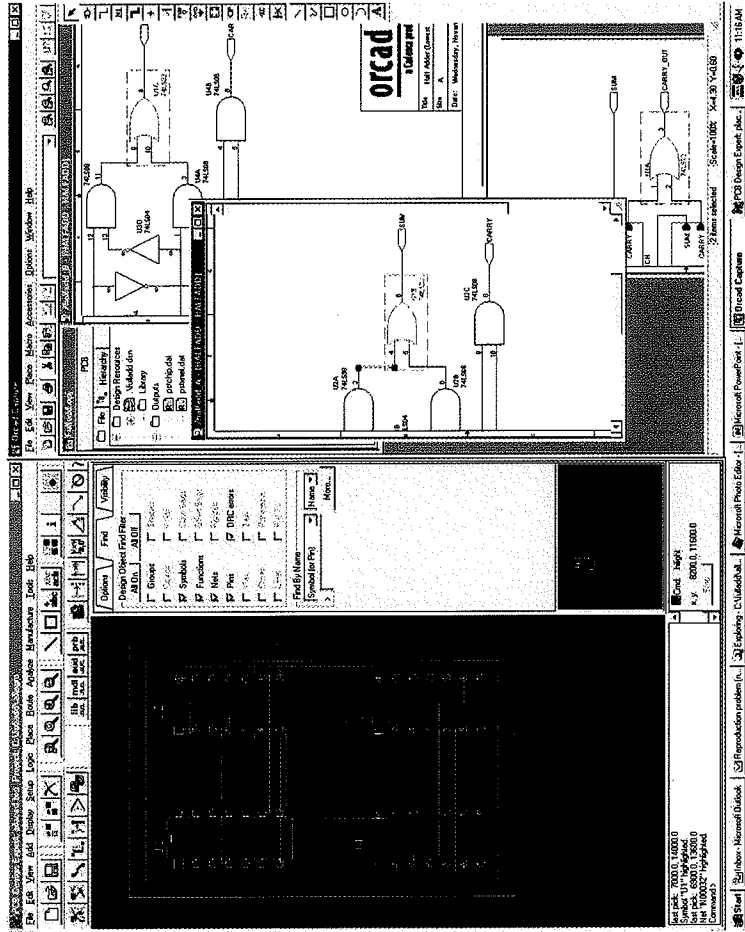
- Understanding of diodes, BJTs, and MOSFETS
- Analysis and design using diodes, BJTs, and MOSFETS in electronic circuits



Drawn by - Bill Bowden - 4/7/99

What you will learn

- Proficiency using tool to design/analyze circuits: PSPICE



Course Expectations

- 10 hours of outside study per week
- Read book
- Understand examples
- Rewrite procedural steps
- Practice!!!

Class Load

Syllabus & tentative schedule outline the workload for this semester. This is a very busy class. Every week will require AT LEAST 10 HOURS of outside studying to pass class.

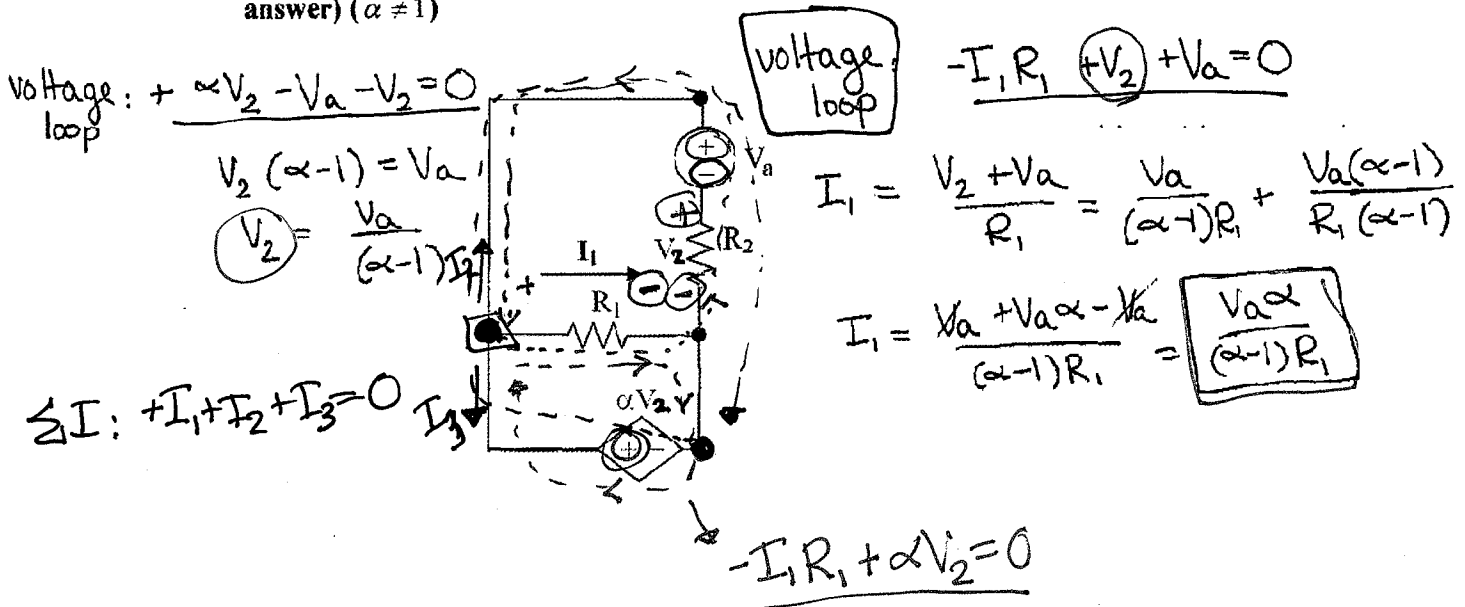
ECE3700 + ECE2280 = Very busy semester – **Organize your time!**

How can you survive??

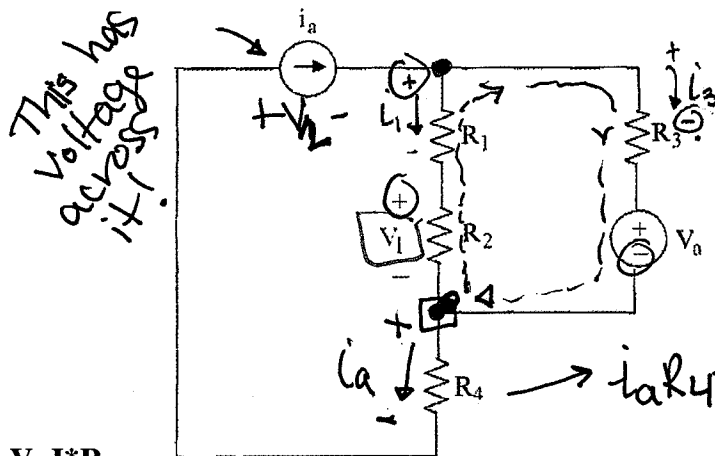
1. Easiest way to get through school is to actually learn and try to retain what you are asked to learn.
 - Even if you're too busy, don't lose your good study practices. What you "just get by" on today will cost you later.
 - Don't fall for the "I'll never need to know this" trap. Sure, much of what you learn you may not use, but some you will need, either in the current class, or future classes, or maybe sometime in your career. Don't waste time second-guessing the curriculum, It'll still be easier to just do your best to learn and retain.
2. Don't fall for the "traps".
 - Homework answers, Extra problem solutions, Posted solutions, Lecture notes.
3. KEEP UP! Use calendar.
4. Make "PERMANENT NOTES" after you've finished a subject and feel that you know it.

REVIEW:

- KVL, KCL, OHM'S LAW, THEVENIN EQUIVALENCE, OPAMPS
 - a. Derive an expression for I_1 . The expression must not contain more than the circuit parameters $\alpha, V_a, R_1,$ and R_2 . (Make sure to eliminate V_2 from the answer) ($\alpha \neq 1$)



Derive an expression for v_1 . The expression must not contain more than the circuit parameters V_a , i_a , R_1 , R_2 , R_3 , and R_4 . (Hint: It is not just a simple voltage divider)



Ohm's Law: $V=I \cdot R$

$$V_1 = i_1 R_2$$

KCL: Summation of currents: $i_a - i_1 - i_3 = 0$ (positive going out of node)

KVL: voltage loop: $+i_1(R_2) + i_1(R_1) - i_3(R_3) - V_a = 0$ (2)

From (1) $\Rightarrow i_3 = i_a - i_1$ (plugging this into (2))

$$i_1(R_1 + R_2) - (i_a - i_1)R_3 - V_a = 0$$

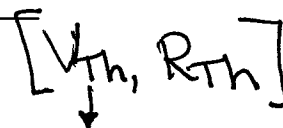
$$i_1(R_1 + R_2 + R_3) = i_a R_3 + V_a$$

$$\therefore i_1 = \frac{i_a R_3 + V_a}{R_1 + R_2 + R_3}$$

$$V_1 = i_1 R_2 = \boxed{\frac{i_a R_3 R_2 + V_a R_2}{R_1 + R_2 + R_3}}$$

Thevenin Equivalence:

- CASE 1: Thevenin Equivalent (circuit with only independent sources)
- Step 1. Turn off all independent sources. (This means $V=0$ (short) and $I=0$ (open))
- Step 2. R_{th} =equivalent R seen between the two desired nodes a-b.
- Step 3. V_{th} = open circuit voltage between a-b.



CASE 2: Thevenin Equivalent (circuit with dependent sources)

- Step 1. Calculate the open circuit voltage, V_{th} . \rightarrow voltage between a-b
 Step 2. Calculate R_{th} . Use only one of the methods below:

Method 1: TEST SOURCE (Always work)

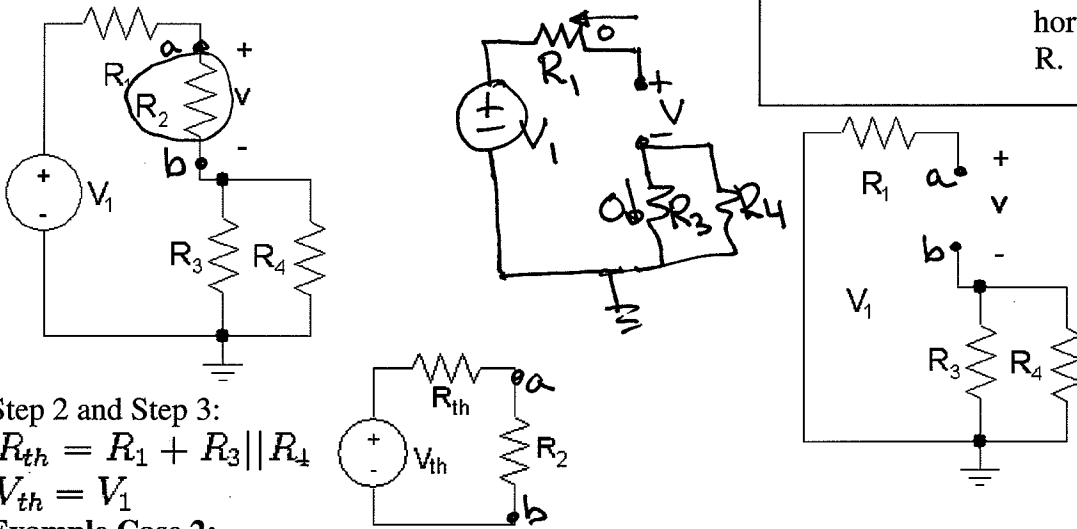
- (a) Remove all independent sources.
 (b) Apply a voltage source V_{test} between a-b and determine the resulting current I_{test} . {OR apply a current source I_{test} between a-b and determine the resulting voltage V_{test} . Using 1V or 1A as the value of the applied test sources allow easy multiplication or division)
 (c) $R_{th} = V_{test} / I_{test}$

Method 2: SHORT CIRCUIT

- (a) Short circuit between a-b and find I_{sc} , short circuit current.
 (b) $R_{Th} = V_{th} / I_{sc}$

Example, Case 1: (independent sources) Find Thevenin across R_2 (Removing R_2 from the circuit).

http://en.wikibooks.org/wiki/Electronics/Thevenin/Norton_Equivalents



independent sources.
 short and $I=0$ (open)
 R_{th}

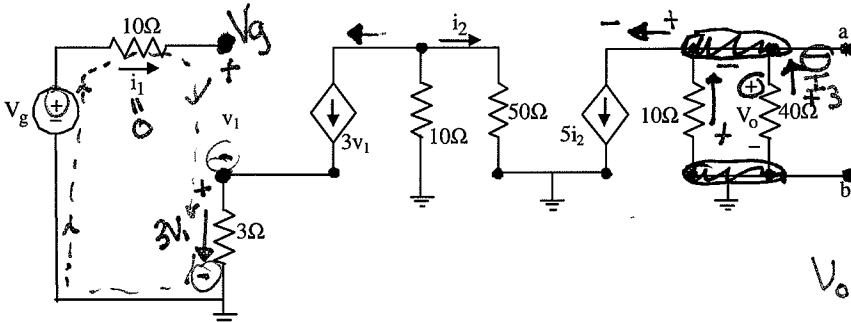
Step 2 and Step 3:

$$R_{th} = R_1 + R_3 || R_4$$

$$V_{th} = V_1$$

Example Case 2:

Find Thevenin between a-b.



Step 1: (Find V_0 (open circuit voltage))

$$V_0 = -5i_2(10 || 40) = -5i_2(10)(40)/50 = -40i_2$$

$$i_2 = -3v_1(10)/60 = -1/2v_1$$

$$V_g - 10i_1 - v_1 - 3v_1(3) = 0 \quad (i_1 = 0) \Rightarrow 10v_1 = V_g$$

$$V_0 = -40(-1/2)(V_g/10) = +2V_g = V_{th}$$

$V_0 = -I_3(40)$ opposite branch
 $I_3 = \frac{5i_2(10)}{(50)}$ total in both branches

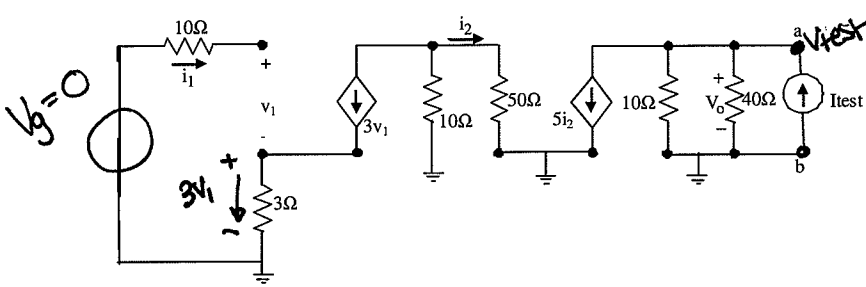
Use for both!

Step 2:

Method 1: TEST SOURCE

(a) Remove all independent sources.

(b) Apply a test source (I_{test} in this case). Analyze circuit for $V_{test}=V_o$ in this case.



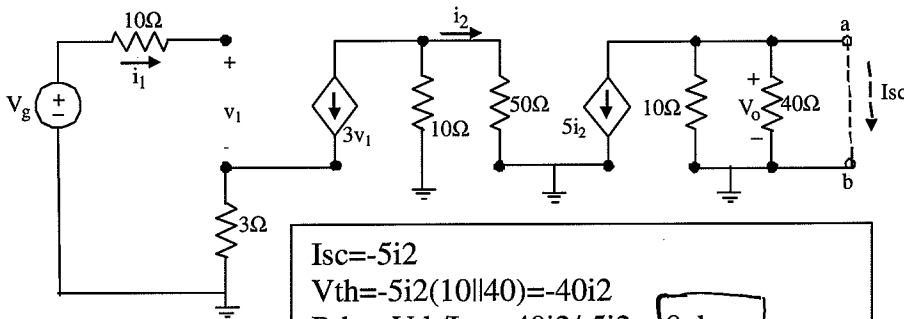
$V_o = V_{test} = (10 \parallel 40) * (I_{test} - 5i_2)$ *sum of currents*

$i_1 = 0$
 $v_1 = -3v_1(3) \Rightarrow v_1 + 9v_1 = 0 \Rightarrow v_1(10) = 0 \Rightarrow v_1 = 0$
 $i_2 = 0$
 $V_{test} = 8I_{test}$
 $R_{th} = 8I_{test}/I_{test} = 8ohm$

(10||40)

Step 2:

Method 2: SHORT CIRCUIT



$I_{sc} = -5i_2$
 $V_{th} = -5i_2(10 \parallel 40) = -40i_2$
 $R_{th} = V_{th}/I_{sc} = -40i_2 / -5i_2 = 8ohm$

SAME

Note: Use of the I_{sc} is sometimes easier than the test source. Suggest trying that method first. Both methods can be used to "check" the other one.

DC Review Notes

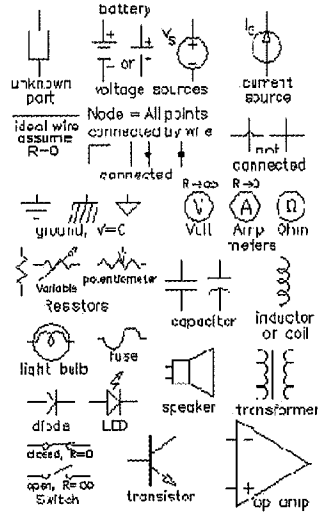
ECE 2100

A.Stop
2/27/20

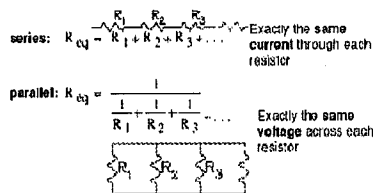
Basic electrical quantities

Charge, actually moves	Unit
Q	Coulomb (C)
Current, like fluid flow	$I = \frac{Q}{s}$ Amp (A, mA, μ A, ...)
Voltage, like pressure	V volt (V, mV, kV, ...)
Resistance	$R = \frac{V}{I}$ Ohm (Ω , k Ω , M Ω , ...)
Power energy/time	$P = V \cdot I$ Watt (W, mW, kW, MW, ...)

Schematic symbols



Resistors and Impedances



Voltage divider:

$V_{R_n} = V_{total} \frac{R_n}{R_1 + R_2 + R_3 + \dots}$

current divider:

$I_{R_n} = I_{total} \frac{\frac{1}{R_n}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots}$

Multiple unknowns:

1. Combine resistors into equivalents where possible.
2. Use superposition if there are multiple sources and you know all the resistors.
3. Use KCL, KVL, & Ohm's laws to write multiple equations and solve.

Non-linear elements:

Assume a linear region and try to solve.

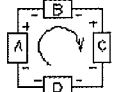
KCL, Kirchoff's current law

$I_{in} = I_{out}$ of any point, part, or section



KVL, Kirchoff's voltage law

$V_{gain} = \sum V_{drops}$ around any loop

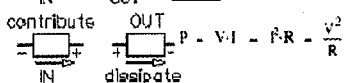


Node = all points connected by wire, all at same voltage (potential)

Ohm's law (resistors)

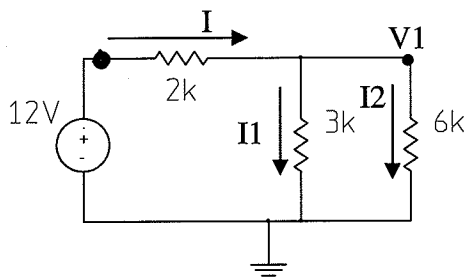
$V = I \cdot R$
 $V = I \cdot R$
 $V = I \cdot R$

Power $P_{IN} = P_{OUT}$ for resistor circuits

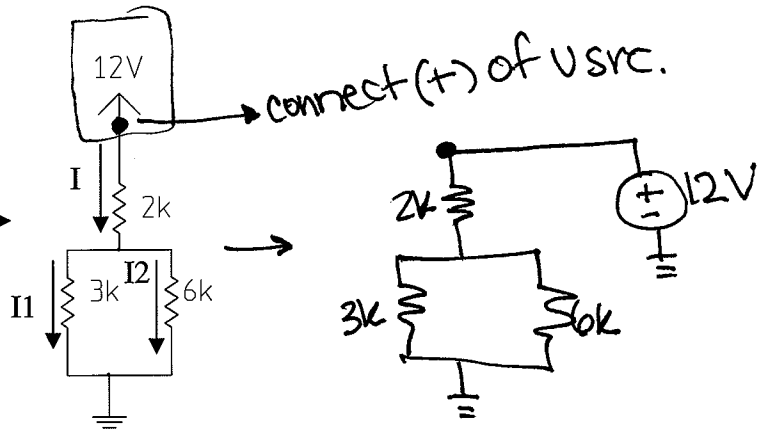


Maximum power transfer: $R_L = |Z_{Th}|$
Load = Thevenin's

Example #3



Same as

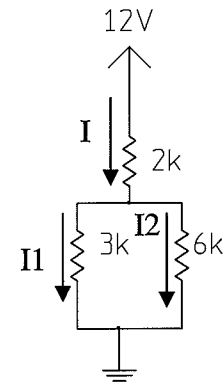


$$\text{Solve for } I, I_1, I_2, \text{ and } V_1: I = \frac{12V}{2k + 3k \parallel 6k} = \frac{12}{2k + \frac{3k(6k)}{3k+6k}} = \frac{12}{2k + 2k} = 3mA$$

$$I_1 = \frac{V_1}{3k}; I_2 = \frac{V_1}{6k}$$

$$I = I_1 + I_2 = V_1 \left(\frac{1}{3k} + \frac{1}{6k} \right) = V_1 \left(\frac{3k}{6k} \right) = V_1 \left(\frac{1}{2k} \right) \Rightarrow V_1 = I \cdot 2k = 3m(2k) = 6V$$

$$I_1 = \frac{6}{3k} = 2mA; I_2 = \frac{6}{6k} = 1mA$$



Example #4

Given $V_g = 6.25mV$, find V_o . Find the Thevenin equivalent between terminals a-b.

