ECE 3200 Electronics II

Spring 2022

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Instructor

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Course Format Summary

This is only a summary; details are provided within this document.

Due dates will be strictly enforced this semester.
Late assignments will not be accepted without prior approval (as possible) and official documentation.

NO FOOD OR DRINK IN LECTURE OR LAB.

ONLY STUDENTS WITH GREEN BADGE STATUS ARE PERMITTED IN LECTURE OR LAB. YOU MUST BE ABLE TO SHOW YOUR BADGE STATUS, particularly at the start of lab.
See https://wmich.edu/covid-19

Lecture.

- This is an in-person class.
  You should attend all in-person lectures (note the possibility of unannounced quizzes).
- Exams will be conducted in-person during the scheduled lecture and final exam times.
- Dr. Miller is available in his office during office hours as posted here.

Laboratories

- In-person lab attendance is MANDATORY during the assigned meeting time. See the course schedule. Lab reports will not be accepted from students that do not attend the associated lab session.
- Lab reports are submitted via ELearning to your lab instructor.
- Pre-lab and post-lab assignments are submitted in lecture.

Note

This syllabus provides a detailed course schedule from which supplemental materials (e.g. lab handouts and previous exams) can be downloaded.

Office Hours

Dr. Miller is available for in-person office hours as posted in his schedule. Appointments at other times are requested by email to damon.miller@wmich.edu.

MEETING TIME	**LAB INSTRUCTOR**	**EMAIL**	**OFFICE HOURS** (start 2nd week of semester)
T 2:30PM-5:10PM	H. Al Ameri	hussein.a.lafta@wmich.edu	After TW lab
W 6:30PM-9:10PM			

Catalog Description

Design, analysis, simulation, and laboratory evaluation of electronic amplifiers, filters, and nonlinear signal shaping circuits composed of transistors, diodes, and integrated circuits. Transient response and steady state frequency response behavior for both small and large signal excitation conditions. Amplifier macro-model description and synthesis is

introduced.
Prerequisites and Corequisites: ECE 2210 and ECE 3100; with a grade of "C" or better in all prerequisites.

Acknowledgements
Some lecture notes (and figures) may be verbatim from the course text or references. ECE faculty members, particularly R. Gejji and J. Gesink, contributed to course materials, including the course syllabus. Dr. Miller also thanks Instructional Designer M. Strock and the Educational Technology Department for contributions to this syllabus as ported from an ECE 2100 syllabus.

Course Topics
[added 1 August 2022]
1. Specifications and parameters
2. Hybrid analog/digital systems, continuous and discrete signals, aliasing, Fourier analysis, single time constant circuits, transient and steady state analysis, amplifier basics
3. Filters
4. Operational amplifier (ideal model, feedback, large and small signal operation and associated models, DC imperfections, frequency effects, applications)
5. Metal-Oxide Field-Effect Transistors (biasing, small and large signal models), current mirrors, MOS integrated circuit amplifiers, active loads, MOS differential amplifiers, CMOS operational amplifier design
6. Amplifier stability (effects of feedback, gain and phase margins, frequency compensation)
7. Hysteresis, sinusoidal oscillators and multivibrators, timers, nonlinear waveshaping circuits

Course Objectives
[added 1 August 2022]
This course develops:
1. an understanding of sampling continuous-time signals, A/D converters, D/A converters, and hybrid analog/digital electronic systems;
2. an ability to analyze, design, simulate, and experimentally validate passive and active linear filters;
3. an ability to analyze, design, simulate, and experimentally validate linear amplifiers;
4. an ability to analyze, design, simulate, and experimentally validate electronic circuits that utilize practical operational amplifiers;
5. an ability to analyze, design, and simulate, electronic circuits utilizing metal-oxide semiconductor field-effect transistors, including MOS-based integrated-circuit operational amplifiers;
6. an understanding of negative and positive feedback systems and their application to electronic circuit analysis and design;
7. apply frequency compensation to electronic circuit design;
8. an ability to design, analyze, simulate, and experimentally validate electronic oscillator circuits;
9. an ability to design, analyze, simulate, and experimentally validate nonlinear waveshaping circuits;
10. an ability to utilize circuit simulation and/or mathematical software tools for electronic design and analysis;
11. an ability to use appropriate statistical measures to characterize experimental error;
12. an ability to use electronic test instrumentation to validate and debug electronic circuits;
13. an ability to prepare effective written technical communications for engineering analysis and design work
14. an ability to thoroughly and accurately document laboratory work using a laboratory notebook; and
15. an ability to function as an effective engineering team member.

Textbook and Materials

Lecture
Required:

1. A. Sedra, K. C. Smith, T. C. Carusone, and V. Gaudet, *Microelectronic Circuits*, Oxford University Press, 8th edition, 2019. Resources for text are at https://learninglink.oup.com/access/sedra8e-student-resources#tag_all-chapters
2. Calculator from the list at https://ncees.org/exams/calculator/

References (also see course schedule):

1. M. E. Van Valkenburg, *Analog Filter Design*, Holt, Rinehart, and Winston, 1982.
2. Sergio Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, 3rd edition, McGraw-Hill, New York, 2002. Errata are available at http://online.sfsu.edu/sfranco/BookOpamp/OpampsErrata.pdf
3. H. Zumbahlen, ed., *Linear Circuit Design Handbook*, 2008, available at https://www.analog.com/en/education/education-library/linear-circuit-design-handbook.html.
4. A. Budak, *Passive and Active Network Analysis and Synthesis*, Houghton Mifflin, 1974.
5. Sedra and K. C. Smith, *Microelectronic Circuits*, Oxford University Press, 3rd edition, 1995.
6. J. A. Cadzow and H. F. Van Landingham, *Signals, Systems, and Transforms*, Prentice-Hall, Inc., New Jersey, 1985.
7. M. Hajimorad and B. Hung, *Bode Plots by [H]and and by [MATLAB®]*, http://www-inst.eecs.berkeley.edu/~ee40/su06/lectures/Bode_Plots.pdf
8. Companion website for course text: https://global.oup.com/us/companion.websites/9780199339136/
9. W. Kester, *What the Nyquist Criterion Means to Your Sampled Data System Design*, Analog Devices Tutorial MT-002, 2008.
10. Weisstein, Eric W. "Fourier Series." From *MathWorld*--A Wolfram Web Resource. http://mathworld.wolfram.com/FourierSeries.html
11. R. Mancini (Editor in Chief), *Op Amps for Everyone*, Texas Instruments, August 2002, available at http://web.mit.edu/6.101/www/reference/op_amps_everyone.pdf
12. B. Bazuin, *Analog and RF Filters Design Manual: A Filter Design Guide by and for WMU Students*, available at https://homepages.wmich.edu/~bazuinb/FiltersManual_RevD.pdf.
13. Alexandra C. Ferguson, *Optimization and Experimental Application of Current Stimuli to Leech Pressure-Sensitive Mechanosensory Cells* (2017). *Masters Theses*. 1131. https://scholarworks.wmich.edu/masters_theses/1131.
14. Lucas M. Essenburg, *Intracellular Electrometer* (2019). *Masters Theses*. 5099. https://scholarworks.wmich.edu/masters_theses/5099.

Recommended:

1. A high level mathematics software suite is useful but not required for course assignments. Such packages are practically indispensable for your senior design project. These packages are typically offered to students at significantly reduced rates. Pick one and master it for use throughout your academic and professional career:
    a. The MathWorks®, *MATLAB® & SIMULINK® (student version)*. This is a tremendous value as this package includes many toolboxes and blocksets that must be purchased separately for use in a professional version. Use this opportunity to learn MATLAB®; this is one of the most widely used software packages, particularly in electrical engineering.
    b. Wolfram Research, *Mathematica®*. This is a remarkable, unified *symbolic* approach to computing. Visit http://www.mathematica.com/ to see some of the extraordinary capabilities of this package developed by Stephen Wolfram.
    c. MapleSoft®, *Maple™*, available on main campus.

2. S. Wolf and R. F. M. Smith, *Student Reference Manual for Electronic Instrumentation Laboratories*, Pearson Prentice Hall, 1990 (1st ed.) or 2004 (2nd ed.). Available for checkout in the ECE office.

Laboratory

Required:

1. R. R. Gejji, J. Gesink, and D. A. Miller, *ECE 3200 Laboratory Manual*. This manual is accessible online at http://homepages.wmich.edu/~miller/ECE3200.html. It is your responsibility to check the manual for updates as the semester progresses.

2. Safety glasses meeting ANSI Z87.1, e.g.
   https://www.elexp.com/catalogsearch/result/?q=060373=
   Glasses must have side protection.
   Students will not be admitted to the lab without safety glasses.
3. Linear Technology**,** *LTspice*, available at no cost at http://www.linear.com/designtools/software/. This software will be used to simulate circuits. You are responsible for ensuring access to a working copy.

   SPICE EXAMPLES
   a. VCCS example (problem 4.43 from Nilsson and Reidel, *Electric Circuits*, 8th ed.)
   b. CCCS and CCVS example (problem 4.51 from Nilsson and Reidel *Electric Circuits*, 8th ed.)
   c. VCVS example (simple operational amplifier model)
   d. Chua's "Simple" Chaotic Circuit (need the National Semiconductor LM741 model available as part of laboratory six in the course schedule below)

4. Laboratory notebook, permanently bound, not loose leaf, 8.5 inches x 11 inches, 60 pages minimum, quadrille ruled (each page has a square grid), **no carbon paper pages**. Two options that should work well:
   a. A "Science Notebook" with college-ruled pages on one side and a grid with 10 squares/inch on the other that was available in the bookstore; or
   b. A Roaring Springs "GRAPH PAPER NOTEBOOK QUAD RULED – 5 SQUARES PER INCH" notebook; or
   c. National Engineering and Science Notebook.

5. Ruler
6. Calculator
7. Pen
8. **Bring** course textbook to lab.

HIGHLY RECOMMENDED
Invest in a quality breadboard NOW. Inexpensive breadboards will cost you precious time in the long run. I have had an excellent experience with 3M Breadboards.

COURSE POLICIES

Academic Honesty
General:

Students are responsible for making themselves aware of and understanding the University policies and procedures that pertain to Academic Honesty. These policies include cheating, fabrication, falsification and forgery, multiple submission, plagiarism, complicity and computer misuse. The academic policies addressing Student Rights and Responsibilities can be found in the Undergraduate Catalog at http://catalog.wmich.edu/index.php?catoid=35 and the Graduate Catalog at http://catalog.wmich.edu/index.php?catoid=39. If there is reason to believe you have been involved in academic dishonesty, you will be referred to the Office of Student Conduct. You will be given the opportunity to review the charge(s) and if you believe you are not responsible, you will have the opportunity for a hearing. You should consult with your instructor if you are uncertain about an issue of academic honesty prior to the submission of an assignment or test.

Students and instructors are responsible for making themselves aware of and abiding by the "Western Michigan University Sexual and Gender-Based Harassment and Violence, Intimate Partner Violence, and Stalking Policy and Procedures" related to prohibited sexual misconduct under Title IX, the Clery Act and the Violence Against Women Act (VAWA) and Campus Safe. Under this policy, responsible employees (including instructors) are required to report claims of sexual misconduct to the Title IX Coordinator or designee (located in the Office of Institutional Equity). Responsible employees are not confidential resources**.** For a complete list of resources and more information about the policy see http://www.wmich.edu/sexualmisconduct.

In addition, students are encouraged to access the Code of Conduct, as well as resources and general academic policies on such issues as diversity, religious observance, and student disabilities:

- Office of Student Conduct http://www.wmich.edu/conduct
- Division of Student Affairs http://www.wmich.edu/students/diversity
- Registrar's Office http://www.wmich.edu/registrar/calendars/interfaith
- Disability Services for Students http://www.wmich.edu/disabilityservices.

— section provided by the WMU Faculty Senate with minor link reformatting

Plagiarism: For an in-depth exploration of plagiarism, see http://libguides.wmich.edu/plagiarism

COVID-19 Statement

Safety requirements are in place to minimize exposure to the Western Michigan University community. These guidelines apply to all in-person and hybrid classes held inside a WMU building to ensure the safety of all students, faculty, and staff during the pandemic. Noncompliance is a violation of the class requirements and the Student Code. https://wmich.edu/conduct/code

Facial coverings (masks), **over both the nose and mouth**, are required for all students while in- class, no matter the size of the space. Following this recommendation can minimize the transmission of the virus, which is spread between people interacting in close proximity through speaking, coughing, or sneezing. During specified classes in which facial coverings (masks) would prevent required class elements, students may remove facial coverings (masks) with instructor permission, in accordance with the exceptions in the Facial Covering (mask) Policy ("such as playing an instrument, acting, singing, etc."). https://wmich.edu/policies/facial-covering-mask

Facial coverings (masks) must remain in place throughout the class. Any student who removes the mandatory facial covering (mask) during class will be required to leave the classroom immediately.

Students who are unable to wear a facial covering (mask) for medical/disability reasons must contact Disability Services for Students before they attend class. https://wmich.edu/disabilityservices

— section provided by the WMU Faculty Senate, highlight added

NO FOOD OR DRINK IN LECTURE OR LAB.

ONLY STUDENTS WITH A GREEN BADGE STATUS ARE PERMITTED IN LECTURE OR LAB. YOU MUST BE ABLE TO DEMONSTRATE YOUR BADGE STATUS, particularly at the start of lab.

Accommodations

If you have a documented disability and verification from the Disability Services for Students (DSS), and wish to discuss academic accommodations, please contact your instructor as soon as possible. It is the student's responsibility to provide documentation of disability to DSS and meet with a DSS counselor to request special accommodation before classes start.

Grading Basis

1. Examinations (2 or more in-semester plus final): 50%
   Requests for early or late examinations will not be approved.
2. Homework and Quizzes (announced or unannounced): 10%
3. Laboratory: 40%

OUTSTANDING WORK might earn extra credit. The first student to report an error in any material prepared by the course instructor will earn extra credit. The course grading scale is:

Scale: 0-60 E | 60-65 D | 65-70 DC | 70-75 C | 75-80 CB | 80-85 B | 85-90 BA | 90-100 A |

Students earning less than a "C" in the laboratory will be assigned a failing course grade.

A grade of "X" will be assigned to any student that earns below 60% and does not complete all examinations including the final.

Midterm grades are not assigned.

Grade Appeals
If you have a question regarding graded course materials (e.g. exam problems, homework problems, laboratory reports, etc.), contact Dr. Miller within **TWO** business days of receiving the grade for the assignment in question.

Late Assignments will not be accepted without a documented excuse. If an emergency prevents you from submitting an assignment on-time, contact your instructor PRIOR to the assignment due date or as soon as you can, via email. Failure to adhere to this policy will result in zero credit for the assignment.

EXAMINATIONS will be closed-notes closed-book. You must have a WMU issued ID with you at the exam. If you observe an apparent incident of academic misconduct, please confidentially alert the course instructor.

Students that exit the exam area during the examination period may not resume taking the exam upon their return. Please address any personal issues prior to the exam session.

Only under extremely unusual circumstances will make-up examinations be considered. If an emergency prevents you from attending a scheduled examination or quiz, contact Dr. Miller via email PRIOR to the test or as soon as you can. Failure to adhere to this policy will result in zero credit for the exercise.

Other
Students are expected to attend all lectures.

LABORATORY
Lab attendance is mandatory.

Students must successfully complete the laboratory safety quiz prior to performing any ECE 3200 experiments. Any indication of failure to follow safe laboratory procedures will result in removal from the lab and course failure.

Only under extremely unusual circumstances will make-up laboratories be considered. Religious observances will be accommodated with advanced notice. If an emergency prevents you from attending a laboratory or arriving on-time, contact your lab instructor via email PRIOR to the lab or as soon as you can. Failure to adhere to this policy will result in zero credit for the lab. Joining or arriving late to lab (i.e. after the posted start time) without a valid excuse may result in zero credit for that lab. *There is no obligation to provide makeup lab sessions for unexcused tardy or absent students*. Students must obtain email approval from Dr. Miller prior to making up a lab.

NOTES ON USING LTspice®:
Set LTspice® to use a white background and black traces (waveform window) and black symbols/wires/text (schematics). DO NOT USE COLOR. Otherwise, your assignments are hard to read and waste ink when printing. Colors are set using Tools->Color Preferences.

Using Tools->Control Panel->Drafting Options set the pen thickness to 2. This improves schematic readability.

Grading Basis
Your laboratory grade will be determined using the following evaluation criteria.

1. EACH student must maintain a notebook to document laboratory work. Lab notebooks provide a convenient and professional method of organizing and storing your lab work and records. Your laboratory notebook will be evaluated for neatness, organization, technical accuracy, and completeness as an appendix to lab reports. Specific guidelines for the notebook will be provided. Unless otherwise indicated, pre-lab assignments must be completed and included in your lab notebook before coming to lab. **Lab notebook pages are attached as an appendix to your lab reports.**

Each laboratory must be initialed by the lab instructor. Signatures will be made in only two cases:

a. The laboratory is complete including the results section (LAB COMPLETE signature);
b. The lab session is over (IN PROGRESS signature). For this case a second LAB COMPLETE signature is required by the end of the next lab session.

Lab reports without signed-off notebook pages will not be accepted.

2. Pre-lab assignments and/or post-lab assignments (30%) [changed from 40% 1/10/2022].
Put a copy of your prelab in your lab notebook.

3. Lab reports (70%) [changed from 80% 1/10/2022].
   c. Unless otherwise noted, each lab team submits one report.
   ECE 3200 LABS ARE COMPLETED INDIVIDUALLY OR IN TEAMS OF TWO.
   No three-person teams.
   d. **USE A WHITE BACKGROUND FOR ALL LTspice® schematics and waveform plots.** Reports must not be handwritten, though you must include copies of your hand-written lab notebook as an appendix.
   e. It is essential that whenever possible *hand analysis*, *simulation*, and *experimental* results be presented side-by-side (using tables or graphs) and errors between these results be quantitatively described. Explain discrepancies.
   f. Whenever possible, present your results in graphical form. One approach is to plot hand analysis and experimental results on top of graphs obtained via simulation. Plot the independent variable along the abscissa and dependent variable(s) along the ordinate. **Do not 'connect-the-dots,' that is, do not connect experimental points with "best-guess" curves unless there is a valid reason for doing so.**
   g. Tables are another effective method of organizing and presenting results.

Your lab report describes ALL OF YOUR LAB WORK and is a STAND-ALONE DOCUMENT, including any LTspice® schematics/results (those can be pasted from LTspice® into a document editor by using 'Tools->Copy bitmap to Clipboard'). The lab report is organized as follows. Use separate section headings for each item.

1. **Title page**

Team Member #1 Name
Team Member #1 Major

Team Member #2 Name
Team Member #2 Major

ECE 3200 Laboratory Report

Title of Experiment
Date Laboratory was Performed

Name of Laboratory Instructor
Day/Time of your lab section

2. **Summary (on separate page):** Brief but complete statement of what you did.

Example:
The complex power of a series-connected ??? Ω resistor (R) and ??? H inductor (L) operating at 60 Hz was investigated. The complex power was determined to be 100 + 100j VA by hand analysis and simulation. Addition of a ??? uF capacitor connected in parallel to the RL load resulted in a unity power factor in both hand analysis and simulation work.

3. **Prelab:** Include the prelab results here after correcting any errors. Whenever possible present results in tabular form. If there is not a prelab assignment include simply indicate N/A in this section.
4. **Results:**

a. Present your results keyed to each step of the laboratory procedure. Include schematics, sketches, plots, etc.
b. Describe what was done and document your results.

5. **Analysis:** Provide response(s) to any end-of-lab questions. If none simply indicate N/A in this section.
6. **Contributions:** List the contributions of each team member to completion of the experiment and report.
7. **Conclusions:** Describe lessons learned.
8. **Lab Notebook:** Attach the related lab notebook pages as an appendix FOR EACH TEAM MEMBER. Team members with poor notebook entries will be penalized.

Style

Observe proper sentence structure, spelling, and punctuation. Use third person, passive voice. Avoid repetition, the obvious, abstractions, and wordiness.

Submission

Unless otherwise noted, each lab team submits ONE PDF report and ONE ZIP file containing supporting files; only one team member submits these two items.

1. Submit your REPORT as a single PDF file to your lab instructor's ELearning Dropbox by the indicated due date for that lab. Name the file as follows:

   "LastNameFirstName_Report_Lab#_SessionDayAndTime"; for example, DoeJane_Report_Lab8_R830.pdf

   is Jane Doe's report submission for her Thursday 8:30 lab team. The lab report is a stand-alone document and includes all of your work, including LTspice® schematics and simulation results.

2. Submit all SUPPORTING FILES (e.g. ALL LTspice® files) used in your lab work to your lab instructor's ELearning Dropbox by the indicated due date for that lab as a single ZIP file. Name the file as follows:

   "LastNameFirstName_SPICE_Lab#_SessionDayAndTime"; for example, "DoeJane_SPICE_Lab8_R830.zip"

   is Jane Doe's supporting files submission for her Thursday 8:30 lab group.

   Submissions not following these instructions will not be accepted.

HOMEWORK

ALL homework assignments will be announced in class and/or posted online. Homework assignments with missing or illegible names will not receive credit and may or may not be returned.

Homework due dates will be given in class. Homework is due at the **beginning** of lecture. Each homework problem must be worked on separate page(s). LATE HOMEWORK will not be accepted, except under extraordinary circumstances. Homework is to be completed individually.

Homework should normally be done on 8 1/2" by 11" sheets. "Engineer's Pad" sheets are preferred. Solutions must be done in a neat, structured, logical, and orderly manner with frequent brief notations enabling the grader to readily verify the author's source of information, steps taken, sources of formula, equations, and methods used. USE THE PARTIAL CHECK LIST FOR SUBMITTED HOMEWORK BELOW. Papers failing to meet these guidelines may not be graded and may be returned, with or without an opportunity for resubmission with a penalty.

PARTIAL CHECK LIST FOR SUBMITTED HOMEWORK

1. Each problem must include: (a) author's name, (b) name/title of the assignment, and (c) date of completion. **PUT YOUR LABORATORY MEETING DAY AND TIME IN THE UPPER RIGHT HAND CORNER.**

2. Use only one side of the paper and include a brief and concise statement of the problem prior to its solution. Begin each problem on a new page.
3. Number the pages and **DOUBLE SPACE** the text.
4. Staple each problem in the upper left corner as needed.
5. Entitle graphs, label and include axes, include key symbols for multiple curve graphs, and give brief notes of explanation where appropriate.
6. Briefly but clearly annotate your document in a way which will provide the document reader with information such as
    a. which part of the assignment is this?
    b. what is being done and why?
    c. how was it done and what are the results?
    d. how was this equation obtained and how was it used?
    e. sample calculations and definitions of symbols/parameters where appropriate; and
    f. **BOX AND LABEL ANSWERS.**

Tentative Course Schedule

The schedule will be frequently updated as the semester progresses.

Yellow highlight indicates item requires future attention.

#	date	topic	assignments
WEEK 1			
NO LAB MEETING **(COMPLETE THE LAB SAFETY MODULE FROM ECE 2100)** Read ECE 2100 Laboratory: Safety and Rules View lecture #6 on electrical laboratory safety on ELearning. Complete and submit the SAFETY QUIZ DUE BY 1/14 5PM to lab instructor ELearning Dropbox.			
1	1/10	Syllabus Course and lab introduction Lab Safety Lab 2 PBF Discussion (with specifications and parameters AND engineering design vs. engineering analysis)	Read syllabus, CH 1 (S&S), Appendix E *Single Time-Constant Circuits* (S&S), http://mathworld.wolfram.com/FourierSeries.html Read Analog Devices tutorial MT-002 "What the Nyquist Criterion Means to Your Sampled Data System Design" by W. Kester available at http://www.analog.com/media/en/training-seminars/tutorials/MT-002.pdf Read all documents related to Labs 1 and 2 Acquire safety glasses Explore http://lib.usm.edu/plagiarism_tutorial.html Lab 2 PBF prelab due 1/19 in lecture HW #1 DUE 1/28 Use LTspice to plot equation 1.2 of S&S for five terms. Set the square wave peak to 1V and frequency 1Hz; do this by using series connected voltage sources of the appropriate frequencies and phases. THEN adjust the phases of the sources so that the approximate square wave is delayed by 250ms (phase delay). Plot the delayed square wave. You cannot simply put a 250ms delay into the sine wave sources – you will get an unacceptable flatline. Use bv sources! S&S Appendix E: 1, 2, 3
2	1/12	Signals and Information Sampling of continuous time signals A/D and D/A converters analog and digital signals A "typical" electronic system (closed-loop neuron membrane voltage controller via current stimulation)	See [Ferguson 2017] and [Essenburg 2019] for details on neuron stimulation
3	1/14	aliasing anti-aliasing filters: ideal and practical sampling ADC	LAB SAFETY QUIZ DUE read CH 2 (S&S)

			See http://www.sosmath.com/fourier/fourier1/fourier1.html for a review of Fourier Series
WEEK 2			
LAB 1: Equipment Familiarization Laboratory ECE3200LaboratoryManualFrontMatter.pdf Prelab due at beginning of lab. Lab 1 exercises due 1/28 at beginning of class Since your signed-off notebook serves as the lab report, no lab report submission is required.			
	1/17	**NO CLASS: MLK DAY RECESS**	
4	1/19	Discuss Lab 1 exercises decade vs. octave frequency change linear systems/superposition	LAB 2 PBF PRELAB DUE IN LECTURE Lab 3 ABF prelab due 1/26 in lecture
5	1/21	Review PBF prelab linear systems/superposition	Redo LAB 2 PBF PRELAB Due in lecture 1/24
WEEK 3			
LAB 2: Passive Bandpass Filter Design f0=1.4kHz;Q=0.3;Tp=-10.5dB REPORT DUE BY 2/4 5PM to lab instructor ELearning Dropbox LAB EXERCISES DUE 2/4 in lecture, one per team. Example: UsingLTspiceToPrepareBodePlot.asc "Bode Plots by hand and by MatLab" (external link) Mathematica® notebook (as a .pdf file) describing how to use Fourier Series to compute output of a RC circuit: FourierSeries.nb As for every lab, place a copy of your pre-lab in your lab notebook.			
6	1/24	frequency spectrum, RMS linear systems: w/ Fourier Series	LAB 2 PBF PRELAB REDO DUE HW #2 S&S DUE 2/9 CH 1: 26, 41, 43, 45, 47, 49, 50, 51, 55, 71, 80, 82 Find the differential equations that correspond to the low pass and high pass transfer functions of Table 1.2 of the text and put in the form dv_o/dt= SOMETHING. Provide an intuitive explanation of the difference between the low pass and high pass filter characteristics using your result.
7	1/26	*Amplitude and Phase Distortion* (Budak, section 16-5) Oscilloscope compensation circuit Reference: F. Najmabadi, *II. Passive Filters*, http://aries.ucsd.edu/NAJMABADI/CLASS/ECE65/06-S/NOTES/filter.pdf	LAB 3 ABF PRELAB DUE IN LECTURE
8	1/28	Discuss LAB 3 Amplifiers: Linearity, Gain, Decibels, Efficiency, Saturation *1.4.8 Symbol Convention*	HW #1 DUE Read S&S CH 17.1-17.3, 17.11 LAB 1 EXERCISES DUE IN LECTURE LAB 1 REPORT DUE
WEEK 4			
Tuesday lab performs this lab this week. Wednesday lab performs this lab WEEK 8. LAB 3: Active Bandpass Filter Design f0=1.4kHz;Q=3;Tp=25.1dB			

NationalSemiconductorModels.lib (contains model of LM741 from National Semiconductor) Put this file in the same directory as your LTspice schematic and put the SPICE directive ".include NationalSemiconductorModels.lib" in your schematic. Place the "opamp2" operational amplifier model part in your schematic, right click on the part, set "SpiceModel" and "Value" to LM741/NS. You need voltage sources for power supplies! REPORT DUE BY 3/18 5PM to lab instructor ELearning Dropbox LAB EXERCISES DUE 3/18 in lecture, one per team			
9	1/31	Amplifiers: Biasing *1.5 Circuit Models for Amplifiers*	Read CH 1 (The Op Amp's Place in the World by R. Mancini) of R. Mancini (Editor in Chief), Op Amps for Everyone, Texas Instruments, August 2002, available at http://web.mit.edu/6.101/www/reference/op_amps_everyone.pdf
10	2/2	Input and Output Resistance *1.6 Amplifier Frequency Response* *1.6.4 Single-Time-Constant Networks*	
11	2/4	*1.6.4 Single-Time-Constant Networks* Low pass filter High pass filter High pass or low pass (Figs. E.4, E.5 S&S)	LAB 2 PBF REPORT DUE LAB 2 PBF EXERCISES DUE IN LECTURE
WEEK 5			
LAB 4A: Transfer Functions, Parameters, and Equivalent Circuits of Linear Amplifiers, Part A R3=1k;R4=22k;R5=510;R6=56k;R7=3.3k;R8=1MEG Prelab: Place prelab in lab notebook prior to lab. Including a table that summarizes the requested data. Include exercises as part of report. REPORT DUE BY 2/18 5PM to lab instructor ELearning Dropbox			
12	2/7	Review Passive Bandpass Filter Laboratory Exercises *Butterworth and Chebyshev Filters* (14.3) [Van Valkenburg, 1982] [Bazuin]	Active Bandpass Filter Prelab Redo DUE 2/11 in lecture (optional) Passive Bandpass Filter Lab Exercise Redo DUE 2/14 in lecture (optional)
13	2/9	*Butterworth and Chebyshev Filters* (14.3) [Van Valkenburg, 1982] [Bazuin] Operational Amplifiers: Introduction, Inverting Amplifier	HW #2 DUE HW #3 (through S&S section 2.5 *Integrators and Differentiators*) DUE 2/21 S&S CH 2: 2, 7, 9, 15, 17, 22, 33, 35, 43, 47, 65, 67, 81, 92, EXTRA CREDIT: 69
14	2/11	Discuss Prelab 4B Operational Amplifier Circuits: Input and Output Resistance, Ideal Integrator	~~LAB 3 ABF REPORT DUE~~ ~~LAB 3 ABF EXERCISES DUE IN LECTURE~~ Active Bandpass Filter Prelab Redo DUE in lecture Read S&S CH 11.2.1, 11.2,2, 11.2.3
WEEK 6			
LAB 4B: Transfer Functions, Parameters, and Equivalent Circuits of Linear Amplifiers, Part B Prelab: Place prelab in lab notebook prior to lab. Include exercises as part of report. REPORT DUE BY 2/25 5PM to lab instructor ELearning Dropbox			
15	2/14	Operational Amplifier Circuits: Practical Integrator, Summer, Differentiator, Non-Inverting Amplifier, Non-Inverting Amplifier as a Negative Feedback System	PBF Exercise REDO DUE in lecture

	2/16	Instructor Absence Please review this material from ECE 2100: Voltage Buffer, OpAmp Voltmeter w/ Meter Movement; Difference Amplifier, CMRR Operational Amplifiers: Instrumentation Amplifier Linear Technology LT1167 Precision Instrumentation Amplifier datasheet NPC-1220 Series NovaSensor Medium Pressure Sensors datasheet Review J. Stahl, Dual Channel Low Noise Amplifier for Experiments In Neurophysiology, Master of Science in Electrical Engineering Thesis, 2009. Review L. Essenburg, Intracellular Electrometer, Master of Science in Electrical Engineering Thesis, 2019.	
	2/18	Instructor Absence	LAB 4a REPORT DUE
WEEK 7			
LAB 4C: Transfer Functions, Parameters, and Equivalent Circuits of Linear Amplifiers, Part C Prelab: Place prelab in lab notebook prior to lab. Include exercises as part of report. The exercises require significant work. REPORT DUE 3/16 IN LECTURE			
16	2/21	Why Procedure 10 of LAB 4b will not work! Discuss LAB 5 Operational Amplifier Circuit: Negative Resistance Circuit	HW #3 DUE HW #4: DUE 3/14 Via the WMU library obtain a copy of the article "Experimental Realization of Observer-Based Hyperchaos Synchronization", D. A. Miller and G. Grassi, *IEEE Transactions on Circuits and Systems – Fundamental Theory and Applications*, vol. 48, no. 3, March 2001. Name at least four different operational amplifier configurations used in Figure 3. S&S: CH 2: from S&S section 2.6 *DC Imperfections*: 94, 98, 107, 108, 112, 115, 121, 125, 126 CH 11: 4, 6, 9, 17, 19 LAB 5 ANTI-ALIASING FILTER PRELAB DUE 3/14 IN LECTURE
17	2/23	Operational Amplifier Circuit: Negative Resistance Circuit Operational Amplifier: Frequency Effects, Gain/Bandwidth Tradeoff	
18	2/25	Exam 1 Review	LAB 4b REPORT DUE
WEEK 8			
TUESDAY SECTION: OPEN LAB **WEDNESDAY SECTION: LAB 3 MAKEUP SESSION** LAB 3: Active Bandpass Filter Design f0=1.4kHz;Q=3;Tp=25.1dB			

NationalSemiconductorModels.lib (contains model of LM741 from National Semiconductor) Put this file in the same directory as your LTspice schematic and put the SPICE directive ".include NationalSemiconductorModels.lib" in your schematic. Place the "opamp2" operational amplifier model part in your schematic, right click on the part, set "SpiceModel" and "Value" to LM741/NS. You need voltage sources for power supplies! REPORT DUE BY 3/18 5PM to lab instructor ELearning Dropbox LAB EXERCISES DUE 3/18 in lecture, one per team			
19	2/28	Operational Amplifier Circuits: Benefits of Feedback: *Gain Desensitivity* (11.2.1), *Bandwidth Extension* (11.2.2), application to non-inverting configuration, Noise Reduction, *Reduction in Nonlinear Distortion* (11.2.3)	LAB 6 AC VOLTMETER DESIGN CONCEPT DUE 3/16 IN LECTURE The design concept must include a working LTspice® simulation.
20	3/2	**EXAM 1** S&S material up to Section 2.5, including: Application of Fourier Series A/D and D/A Converters Nyquist Rate/Sampling Frequency Using Amplifier Models of S&S Table 1.1 STC Networks (S&S Table 1.2)/Bode Plots Oscilloscope Frequency Compensation Ideal Op-Amp Circuits Instrumentation Amplifier Operational Amplifiers Circuits as Negative Feedback Systems/Closed-Loop Gain Integrators/Differentiators Exam #1 Spring 2018 Exam #2 Spring 2018 Exam #1 Spring 2020 Exam #1 Spring 2021 NOTE: for practice only; your exam might not look anything like these	Review MOSFETs (S&S CH 5), particularly their VI curves, operating modes, use as a linear amplifier, and small-signal models. Read S&S CH 7.1. 7.2.1, 7.4.1, 7.5.1 Read S&S CH 8 to 8.2, CMOS material only, Example 8.3 Read S&S CH 9.1, 9.5.2, 9.5.3, 9.6.1
	3/4	**NO CLASS: SPIRIT DAY RECESS**	
WEEK 9			
LAB 5: Anti-Aliasing Filter Design Report due 3/28 in lecture Best overall design project will earn a coveted *ECE 3200 Best Design Award*			
21	3/14	Bird in room (really) Review Graded Exam 1	LAB 5 ANTI-ALIASING FILTER PRELAB DUE IN LECTURE HW #4 DUE
22	3/16	These sections are available from https://iws.oupsupport.com/protected/files/content/file/1581691089623-Sedra8e_BonusTextTopics-x7.pdf *Nonlinear Waveform-Shaping Circuits* (x7.3) *Precision Rectifier Circuits*, including AC voltmeter (x7.4) Discuss LAB 6 Operational Amplifier Circuits: Benefits of Feedback: Noise Reduction, *Reduction in Nonlinear Distortion* (11.2.3) Operational Amplifiers: *DC Imperfections* (2.6): *Offset Voltage* (2.6.1)	LAB 4c REPORT DUE IN LECTURE

23	3/18	Operational Amplifiers: *DC Imperfections* (2.6): *Offset Voltage* (2.6.1); *Input Bias and Offset Currents* (2.6.2) Operational Amplifiers: Large-Signal Operation (2.8), slew-rate limiting	LAB 3 ABF REPORT DUE LAB 3 ABF EXERCISES DUE IN LECTURE
WEEK 10			
Lab 6: AC Voltmeter (DESIGN PROJECT) Report due 4/11 in lecture The report must include AS THE LAST AND SEPARATE PAGE a one-paragraph description for each team member of the contributions made to the design project. Reports without this page will not be accepted. Best overall design project will earn a coveted *ECE 3200 Best Design Award*			
24	3/21	Operational Amplifiers: CMRR: inverting/non-inverting configurations Input and Output Resistance **LAST DAY TO WITHDRAW**	LAB 6 AC VOLTMETER CONCEPT DUE IN LECTURE
25	3/23	NMOS MOSFET formulas and curves Example MOSFET Simulations NMOS MOSFET: large and small signal operation NMOS amplifier	
26	3/25	NMOS amplifier PMOS MOSFET curves/amplifier	HW #5: DUE 4/13 S&S: 7.25, 7.33, 7.95, 8.2, 8.6. Redo Example 8.3 without using absolute values, 9.1, 9.86.
WEEK 11			
Lab 6: AC Voltmeter (DESIGN PROJECT) Report due 4/11 in lecture. The report must include AS THE LAST AND SEPARATE PAGE a one-paragraph description for each team member of the contributions made to the design project. Reports without this page will not be accepted. Best overall design project will earn a coveted *ECE 3200 Best Design Award*			
27	3/28	PMOS MOSFET curves/amplifier *Biasing MOSFETS (7.4)* *IC Design Philosophy (8.1)* *The Basic MOSFET Current Source* (8.2.1)	LAB 5 ANTI-ALIASING LAB REPORT DUE IN LECTURE
28	3/30	Review Lab 5 Report *The Basic MOSFET Current Source* (8.2.1) *MOS Current-Steering Circuits* (8.2.2)	
29	4/1	Example 8.4 (CS amplifier) Stability and Frequency Compensation in Negative Feedback Systems	
WEEK 12			
LAB 7: Frequency Compensation of an Operational Amplifier Report due 4/20 by 5PM to lab instructor ELearning Dropbox			
30	4/4	Stability and Frequency Compensation in Negative Feedback Systems	
31	4/6	*MOS Differential Pair* (9.1) *The Current-Mirror-Loaded* [Active-Loaded] *MOS Differential Pair* (9.5.2)	
32	4/8	*The Current-Mirror-Loaded* [Active-Loaded] *MOS Differential Pair* (9.5.2) *A Two Stage CMOS Op Amp* (9.61)	Read S&S 15.1, 15.2.1, 15.2.4, 15.4
WEEK 13			
LAB 8: CMOS Operational Amplifier Report due 4/22 5PM to lab instructor ELearning Dropbox			

33	4/11	*A Two Stage CMOS Op Amp* (9.61) Review lab assignments	LAB 6 AC VOLTMETER LAB REPORT DUE IN LECTURE
34	4/13	Review previous exam problems	HW #5 DUE
35	4/15	Review previous exam problems	
WEEK 14			
LAB 9: Oscillator Circuits Prelab: Place in lab notebook. Simply scan and submit your lab notebook by 5PM 4/22 to ELearning Dropbox as your report			
36	4/18	**EXAM 2** YOU CAN USE **ONE SIDE** OF A 3"x5" INDEX CARD AS A NOTE CARD FOR THE EXAM Includes EXAM 1 TOPICS Op Amp Nonideal Characteristics (offset voltage, bias currents, input resistance, output resistance, finite bandwidth, etc.) MOSFETs: characteristics MOSFET circuits: current mirror, CS amplifier Frequency compensation Exam #2 Summer I 2012 Exam #3 Spring 2018 Exam #2 Spring 2021 NOTE: for practice only; your exam might not look anything like these	
37	4/20	Review lab assignment ~~*Basic Principles of Sinusoidal Oscillators* (15.1)~~ ~~*The Wien-Bridge Oscillator* (15.2.1)~~ ~~See note on page 1390 RE Hewlett Packard's first product the HP200A. The manual is worth a look.~~ ~~*The Active-Filter-Tuned Oscillator* (15.2.4)~~ ~~LM 555 timer~~	LAB 7 FREQUENCY COMPENSATION LAB REPORT DUE
38	4/22	Review Graded Exam 2 Final Exam Review Course wrap-up Encourage instructor evaluation participation Consider accelerated master's program in EE or CpE!!!	LAB 8 CMOS OA LAB REPORT DUE LAB 9 NOTEBOOK SCAN DUE
WEEK 15			
39	WED 4/27	**FINAL EXAM** 10:15AM to 12:15pm Verify date/time on your own. cumulative YOU CAN USE **ONE SIDE** OF A 3"x5" INDEX CARD AS A NOTE CARD FOR THE EXAM **example** topics: Exams 1-2 Transfer Functions, Parameters, and Equivalent Circuits of Linear Amplifiers Lab Part C CMOS Amplifiers/Op Amp LP/HP Op Amp circuits frequency compensation Final Exam Spring 2018 Final Exam Spring 2021	

		NOTE: for practice only; your exam might not look anything like these	