ECE 321: Electronics II Analog Electronics

Please visit Bison Academy for corresponding lecture notes, homework sets, and solutions

What are Analog Electronics?

ECE 320: Digital Electronics (week 1-10)

- Binary outputs: 5V (true) or 0V (false)
- Transistors were either saturated or off
- Topics: Transistor switches, H-bridges, Diodes, AC to DC converters, ...

ECE 321: Analog Electronics (week 11-16)

- Analog outputs: -10V to +10V continuous
- Transistors operate in the active region:
- Topics: Amplifiers and Mixers, Power Amplifiers, Sensors, Filters



Overall, this is a fun course: by the end you should be able to build:

- A subwoofer:
- An Octolively:
- An 8-Key Piano with sinusoidal outputs
- A temperature-controlled fan



yPlaying Jungle Bells over a Light Beam

Fall 2018

An audio signal is transmitted over a light beam using amplitude modulation. A LDR sensor picks up the light sensor, which is then low-pass filtered with a 5thorder Chebychev low-pass filter. A push-pull amplifier then drives an 8 Ohm speaker.

Syllabus

• www.BisonAcademy.com

Week 1: Op-Amp Amplifiers and Mixers.

- Amplify and mix analog signals (Katy Perry & Devo)
- Drive an 8-ohm speaker

Week 2: Sensors and Instrumentation.

- Measure temperature, light, etc
- Output -10V to +10V

Week 3 & 4: Filters

- Pass low frequencies (subwoofer)
- Pass 610Hz (cow-bell filter)

Week 5&6: Transistor Amplifiers

• Build an amplifier at the transistor level

	Date	Lecture
М	Mar 27	Intro to ECE 321 Slides #0
W	Mar 29	Op-Amps and Analog Circuits Slides #1
Ih	Mar 30	Amplifiers and Mixers Slides #2
F	Mar 31	Push-Pull Amplifiers Slides #3
М	Apr 3	Temperature Sensors Slides #4
We	Apr 5	Audio & Strain Sensors Slides #5
Th	Apr 6	Quiz #1
F	Apr 7	Holiday
М	Apr 10	Holiday
W	Apr 12	Calibration & Noise Slides #6
Ih	Apr 13	Active Filters Slides #7
F	Apr 14	Poles, Zeros, and Frequency Response _{Slides #8}
М	Apr 17	Butterworth, <u>Chebychev</u> , Elliptic Filters _{Slides #9}
W	Apr 19	Filter Design Example Slides #10
Th	Apr 20	Quiz #2
F	Apr 21	Analog Computers

Course Information:

Instructor:

• Ivan Lima

Class Times

- Tu / Th / Fr
- In-Person as well as on Zoom

Labs:

- Part of homework sets
- Lab kits needed for each student
- Extra parts are provided for each student

Office Hours:

• t.b.d.

Bulletin Description:

ECE 320: Characterization, modeling, and analysis of digital circuits using diodes, BJTs, FETs, and Op Amps. 4 one-hour lectures, 1 two-hour laboratory each week for 10 weeks. Prereq: EE 206. F, S

• ECE 320 is required for all electrical and computer engineers. Everyone should sign up for ECE 320.

ECE 321: Characterization, modeling, and analysis of analog circuits using diodes, BJTs, FETs, and Op Amps. 4 one-hour lecture, 1 two-hour laboratory each week for 6 weeks. Prereq: EE 206. F, S

• ECE 321 is required for all electrical engineers and is optional for computer engineers. It counts as a 2cr technical elective for computer engineers.

ECE 321 Course Objectives:

By the end of the semester, students should:

- Explain how to put a transistor into the active region
- Design and analyze transistor circuits with analog inputs and outputs,
- Design and analyze filters to meet design requirements, and
- Design an analyze op-amp circuits with analog inputs and outputs





Required Student Resources:

- Calculator capable of complex numbers
 - HP35S recommended
 - Most ECE students use TI84 Plus
- Ability to make videos and preferably post them on YouTube.
- CircuitLab account
 - free if you use your NDSU email account
 - Register at www.CircuitLab.com

If you are doing the labs off-campus

- MultiMeter that can read 1VAC
 - \$29 from Amazon.
- Electronics Kits (\$18 from Amazon)
- Extra parts (pick up from ECE 201)
- +/- DC Power Supply
 - CADET boards work for on campus students
 - Two 9V batteries work for off-campus students



Evaluation Procedures and Grading Criteria

Grades will be the average of the following:

	Weekly Quizzes	Homework	Final Exam
ECE 321	33%	33%	33%

Grades are rounded to the nearest 1%, with your final grade being

F	D	С	В	А
59% or less	60% - 69%	70% - 79%	80% - 89%	90% or more

Text Book

www.BisonAcademy.com

- Free
- What most students use

www.electronics-tutorials.ws

• Good web site with lots of ECE material

Microelectronic Circuit Design

- Richard C. Jaeger
- Any edition works
- \$9.49 used
- optional if you want a hardcopy

BISON ACADEMY

Advising Info ECE Lab Supplies (new) ECE 111: Intro to ECE ECE 206: Circuits I ECE 311: Circuits II ECE 320: Digital Electronics ECE 321: Analog Electronics ECE 331: Energy Conversion ECE 341: Random Processes ECE 343: Signals and Systems ECE 343: Signals and Systems ECE 461: Controls Systems ECE 463: Modern Control ECE487 Cardiovascular Engineering ECE 494: Robotics



ECE LABS

Microelectronic Circuit Design with CD-ROM 2nd Edition

by Richard C. Jaeger (Author), Travis N. Blalock (Author)
★★★☆☆ ← 6 ratings



Lab Kits

Homeworks usually have three parts:

- Design on paper
- Simulate using CircuitLab
- Build in hardware

Hardware can be done on campus

• parts in room 211 & 237

Or at home.

- Parts kit from Amazon
- Extra parts (pick up in ECE 201 for free)
- Multimeter that can measure 2VAC
- Two 9V batterys work (+/- 9V)





Digital Multimeter, LOMVUM TRMS 6000 Counts Electrical Tester AC/DC Amp Ohm Voltage Tester Meter with Temperature Frequency Resistance Continuity Capacitance Diode and Transistor Test Visit the Lomvum Store

List Price: \$49.99 Details Price: \$27.99 & FREE Returns * You Save: \$22.00 (44%)

Get \$60 off instantly: Pay **\$0.00 \$27.99 upon approval for the Amazon Prime** Store Card. No annual fee.

Pattern Name: T28C

Textbook: Bison Academy

- Topics covered each day
- Lecture notes in portrait and landscape format (pdf)
- Recorded lectures for online students (or anyone) YouTube link
- Handouts and solutions that we go over in class
- Weekly homework and solutions to the homework (pdf)

	Date	Lecture	Videos YouTube <u>PlayList</u>	Handouts	Homework	
М	Oct	Intro to ECE 321 Slides #0	0: Intro to ECE 321		LI\\/ #1	
W	Nov 1	Op-Amps and Analog Circuits Slides #1	1: Op-Amps	Op-Amps	HW1 Breadboard (Photo)	
Th	Nov 2	Amplifiers and Mixers Slides #2	2: Amplifiers	Inst Amp	HW1 Demo (YouTube)	
F	Nov 3	Push-Pull Amplifiers Slides #3	3: Push-Pull Power Amp (electroboom)	Push-Pull Amp	LM376-3 Datasheets	
М	Nov 6	Temperature Sensors Slides #4	4. Temperature Sensors Peltier Cooling (electroboom)	Thermistors		
We	Nov 8	Active Filters Slides #7	7. Active Filters	Active Filters	HW #2	
Th	Nov 9	Quiz #1			HVV2 Breadboard (photo)	
F	Nov 10	Holiday -				

Bison Academy - Homework Sets & Solutions

Homework sets and solutions from previous semesters

- Makes good sample problems to work on
- Solutions to these homework sets let you check your answers
- Solutions also useful if you get stuck on a homework problem

Quizzes and solutions fom previous semesters

Sp23	Sp 22	Fa21	Sp 21
HW #1	HW #1	1: Push-Pull	1: OpAmps
Solution #1 (pdf)	Solution #1 (pdf)	Solution #1 (pdf)	Solution #1
Solution #1 (YouTube)	Solution #1 (YouTube)	Solution #1 (YouTube)	Quiz #1
	Quiz #1	Quiz #1	Quiz #1 Solution
	Quiz #1 Solution (pdf)	Quiz #1 Solution (pdf)	
	Quiz #1 (YouTube)	Quiz #1 (YouTube)	
HW #2	HW #2	2: Sensors	2: Push-Pull & Sensors
Solution #2 (pdf)	Solution #2 (pdf)	Solution #2 (pdf)	Solution #2
Solution #12 (YouTube)	Solution #2 (YouTube)	Solution #2 (YouTube)	Quiz #2
Quiz #1	Quiz #2		Quiz #2 Solutions
Quiz #1 Solution (pdf)	Quiz #2 Solution (pdf)		
Quiz #1 (YouTube)	Quiz #2 (YouTube)		
HW #3	HW #3	3: Filters	3: Active Filters
Solution #3 (pdf)	Solution #3 (pdf)	Solution #3 (pdf)	Solution #3
Solution #3 (YouTube)	Solution #3 (YouTube)	Solution #3 (YouTube)	Quiz #3
Quiz #2	Quiz #3	Quiz #3	Quiz #3 Solution
Quiz #2 Solution (pdf)	Quiz #3 Solution (pdf)	Quiz #3 Solution (pdf)	
Quiz #2 (YouTube)	Quiz #3 (YouTube)	Quiz #3 (YouTube)	

Bison Academy - Best of ECE 321

Homework sets usually contain three parts

- Design on paper
- Simulate in CircuitLab
- Build and demonstrate in hardware

Making a YouTube video works pretty well for demonstrating your hardware

- YouTube videos also work well for demonstrating your skills to employers
- Place YouTube link on your resume.

Better YouTube videos linked on Bison Academy (with student's permission)



Electronically Turning On and Off a Fan

Spring 2018

A Schmitt Trigger along with a transistor swit replace the resistor with a light sensor or tem fan based upon light level or temperature.



DTL NAND Gate

Fall 2014 A DTL logic gate is built using transistors and

ECE 321: Analog Electronics



Bass Boost

Spring 2015 The audio signal from a computer (or cell phc subwoofer. A 3rd-order Butterworth filter is u amplifier boosts the voltages. A push-pull am



Electronic Candle

Fall 2018

An electronic circuit is built to simulate a flick generator (from a cell phone app) is mixed wi through a push-pull amplifier with a current c

Weekly Quizzes

Typical week in ECE 321:

- Lecture on 3 topics
- Class handouts each day (practice problems)
- Do homework solving similar problems (Mo)
- Go over the homework on Wednesday
- Quiz on that material

Quizzes are usually Thursdays

- Posted on Blackboard
- 2 hour time limit
- Can start any time from 6am to 10pm
- Each quiz is different
- Working together or using Chegg is not allowed

	Date	Lecture
М	Oct	Intro to ECE 321 Slides #0
W	Nov 1	Op-Amps and Analog Circuits Slides #1
Th	Nov 2	Amplifiers and Mixers Slides #2
F	Nov 3	Push-Pull Amplifiers Slides #3
М	Nov 6	Temperature Sensors Slides #4
We	Nov 8	Active Filters Slides #7
Th	Nov 9	Quiz #1
F	Nov 10	Holiday -
М	Nov 13	Poles, Zeros, and Frequency Response _{Slides #8}
W	Nov 15	Butterworth, Chebychev, Elliptic Filters Slides #9
Th	Nov 16	Filter Design Example Slides #10
F	Nov 17	Quiz #2
М	Nov 20	Analog Computers Slides #11
W	Nov 22	Holiday -
Ih	Nov 23	Holiday -
F	Nov 24	Holiday

Hy-Flex Model

Electronics II is offered three ways this semester:

- In-Person: All students are welcome to attend class in person.
- Live-Stream: Zoom link will be posted on BlackBoard and emailed to each student
- On-Line: YouTube videos of each lecture are posted on Bison Academy

Students are welcome to attend however they like each day. Whatever fits your schedule.

You can also attend lectures & take quizzes any way you like.

- Quizzes and final exam can be taken in class
 - Work problems in any order
 - 50 minute time limit
- They can be taken on BlackBoard as well
 - 8am-10pm on quiz day
 - Random order for questions
 - No back-tracking
- 100 minute time limit (to compensate for no back-tracking & scanning answers)

Legal Stuff:

- Special Needs Any students with disabilities or other special needs, who need special accommodations in this course, are invited to share these concerns or requests with the instructor and contact the Disability Services Office (www.ndsu.edu/disabilityservices) as soon as possible.
- Academic Honesty The academic community is operated on the basis of honesty, integrity, and fair play. NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.
- Academic Honesty Defined: All written and oral presentations must "respect the intellectual rights of others. Statements lifted verbatim from publications must be cited as quotations. Ideas, summaries or paraphrased material, and other information taken from the literature must be properly referenced" (Guidelines for the Presentation of Disquisitions, NDSU Graduate School).
- ECE Honor Code: On my honor I will not give nor receive unauthorized assistance in completing assignments and work submitted for review or assessment. Furthermore, I understand the requirements in the College of Engineering Honor System and accept the responsibility I have to complete all my work with complete integrity.
- Veterans and Student Soldiers: Veterans and student soldiers with special circumstances or who are activated are encouraged to notify the instructor in advance.
- Attendance: According to NDSU Policy 333 (www.ndsu.edu/fileadmin/policy/333.pdf), attendance in classes is expected. Students are responsible for the material covered in class and in assignments regardless of their attendance.