Electronics for Scientists V85-0110 and G85-1500 (Spring 2007)

Instructor: Prof. Andrew Kent
Laboratory Instructor: N/A
Prerequisites: Physics II or permission of the instructor
Lecture and laboratory, 4 points

Meeting: Monday 5-5:30 PM, room 901 Meyer
Laboratory: Monday and Tuesday 9-11:15 AM, room 221 Meyer

Course Description:

Introduction to basic analog and digital electronics used in modern experiment and computers for students of all science disciplines, mainly in a laboratory setting. Basic concepts and devices presented in lecture are studied in the laboratory. The course covers filters, power supplies, operational amplifiers, digital logic gates, combinatorial and sequential digital circuits, and computers. Students learn the functions of modern electronic components as well as how they are used in laboratory instrumentation and measurement.

Who Should Take It

Students interested in learning about the operation of modern electronic circuits and their use —particularly, undergraduate and graduate students with concentrations in experimental and computer science.

Main Text:

" The Art of Electronics," P. Horowitz and W. Hill, (Cambridge, University Press, 2nd Edition)

Laboratory Texts:

"Student Manual for the Art of Electronics," T. C. Hayes and P. Horowitz (Cambridge University Press).

Supplementary Notes, A. D. Kent

Web-site: http://classes.nyu.edu

Contact Information

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Electronics for Scientists Syllabus

Lab 1. DC Circuits

Topics: Kirchhoff's Laws, Ohm's Law, non-linear devices, voltage dividers, Thevenin's and Norton models, electrical measurements; introduction to the breadboard and oscilloscope.

Reading: Main text: Chapter 1, sec. 1.00 to 1.10 (pp. 1 to 20), Appendices A and C
Student Manual: Class 1 (p. 1 –31)

Exercises: 1.1 to 1.11 (main text)

Labs: Complete 1.1 to 1.6 (beginning on p. 24)

Lab 2. AC Circuits

Capacitors and inductors, analysis in the time domain, generalized impedance and analysis in the frequency domain, phasor diagrams, differentiators, integrators, high pass, low pass, trap and notch filters.

Reading: Main text Chapter 1, sec. 1.11 to 1.24 (pp. 20 to 44), Appendix B
Student Manual: Class 2 (pp. 32–60)

Exercises: 1.13–1.26 (omit 1.22)

Labs: 2.1 to 2.8 (beginning on p. 54)

Lab 3. Diode Circuits and Power Supplies

Transformers, diodes, load lines, Converting ac to dc power–half and full wave rectifiers, ripple, diode clamps and limiters.

Reading: Main text finish reading Chapter 1, sec. 1.25 to 1.34 (pp. 44 to 59)
Student Manual: Class 4 (pp. 61–81)

Exercises: 1.27, 1.28, and 1.30

Labs: 3.1 to 3.7 (beginning on p. 75)

Lab 4. Transistors I

Simple models of transistor operation, transistor followers, current source, common-emitter amplifier

Reading: Main text Chapter 2, sec. 2.00 to 2.07 (pp. 61 to 77)
Student Manual: Class 3 (pp. 82–99)

Exercises: 2.1 and 2.2

Lab 5. Introduction to Operational Amplifiers

Feedback, negative feedback, basic characteristics of operational amplifiers, op-amp "golden rules", inverting amplifier, follower, non-inverting, input and output impedance, current source, current to voltage converter, summing amplifiers.

Reading: Main text Chapter 4, sec. 4.01-4.09 (pp. 175 to 187)
Student Manual: Class 8 (pp. 166 to 183)
Exercises: 4.1 to 4.5

Labs: 8.1 to 8.7 (beginning on p. 177)

Lab 6. More Operational Amplifiers

Integrators, differentiators, some op-amp limitations and departures from the ideal.

Reading: Main text: Chapter 4, sec. 4.11 and 4.12 (pp. 189 to 210)
Student Manual: Class 9 (pp. 184 to 199)
Exercises: None

Labs: 9.2 to 9.4 (beginning on p. 202)

Lab 7. Positive Feedback

Positive feedback, comparators, Schmitt trigger, oscillators.

Reading: Main text Chapter 4, sec. 4.23 to 4.26 (pp. 229 to 236)
Student Manual: Class 10 (pp. 207 to 231)
Exercises: 4.10 and 4.11

Labs: 10.1, 10.2 and 10.6 (beginning on p. 234)

Lab 8. Introduction to Combinatorial Digital Electronics

Logic states, binary representations, Boolean algebra, logic gates, universal gates, combinatorial digital logic.

Reading: Main text Chapter 8, sec 8.01 to 8.13 (pp. 471 to 493)
Student Manual: Class 13 (pp. 283 to 308)
Exercises: 8.1 to 8.9, 8.11 to 8.13

Labs: 13.1 and 13.2 (beginning on p. 309)

Lab 9. Sequential Digital Electronics

Sequential digital logic, flip-flops, latches and registers.

Reading: Main text Chapter 8, sec 8.16 to 8.19 (pp. 504 to 517) focus on sec. 8.16, 8.17
Student Manual: Class 14 (pp. 320 to 333)
Exercises: 8.24 and 8.25

Labs: 14.1 to 14.6 (skip 14.5) (beginning on p. 334)

Lab 10. Counters

Counters

Reading: Main text Chapter 8, sec 8.24 to 8.26* (pp. 523 to 527)
Student Manual: Class 15 (pp. 342 to 362)
Exercises: None (follow worked exercises in the Student Manual p. 351)

Labs 15.1 to 15.5 (beginning on p. 362)

*For this lab the material in the book is not that relevant, focus on the text in the student manual.

Lab 11. Elements of a Computer

Memory, Buses and State Machines

Reading: Main text Chapter 8, sec 8.18 (again) concentrating on state machines. (pp 512 to 516)
Student Manual: Class 16 (pp. 375 to 402)
Exercises: None

Labs 16.1 to 16.3 (beginning on p. 394)

Electronics for Scientists Syllabus

DC circuits

Kirchhoff's Laws, Ohm's Law, non-linear devices, voltage dividers, Thevenin's and Norton models, electrical measurements.

AC circuits

Reactive components (capacitors and inductors), analysis in the time domain, generalized impedance and analysis in the frequency domain (phasors), differentiators, integrators, high pass, low pass, trap and notch filters.

Diode circuits and power supplies

Transformers, diodes, load lines, ac to dc power conversion–half and full wave rectifiers, ripple, diode clamps and limiters.

Transistors

Simple models of transistor operation, transistor followers, current source, common-emitter amplifier

Operational amplifiers

Feedback, negative feedback, basic characteristics of operational amplifiers, op-amp "golden rules," inverting amplifier, follower, non-inverting, input and output impedance, current source, current to voltage converter, summing amplifiers. Integrators, differentiators, op-amp limitations.

Positive feedback

Positive feedback, comparators, Schmitt trigger, oscillators.

Introduction to combinatorial digital electronics

Logic states, binary representations, Boolean algebra, logic gates, universal gates, combinatorial digital logic.

Sequential digital electronics

Sequential digital logic, flip-flops, latches and registers.

Counters

Counters

Elements of a Computer

Memory, Buses and State Machines