Syllabus:
This is a comprehensive undergraduate level course on microelectronics. Topics covered include
Basic semiconductor physics
Electrons and holes in semiconductors
Electrical transport in semiconductors
PN junctions and diodes
MOS capacitors
MOS field effect transistors
Bipolar junction transistors
Large signal and small signal models of electronic devices
Single stage amplifiers, multistage amplifiers, differential amplifiers
Analog circuit analysis and design
High-frequency models of devices and high-frequency circuit analysis
Digital logic and MOS logic devices,
Complimentary MOS (or CMOS) logic gates
Fundamental trade-offs in high speed analog and digital circuit design
Course Website and Homeworks

• All course documents, including:
  - Lecture notes
  - Homeworks and solutions
  - Exam solutions
  - Extra course related material
  - Labs

will appear on the course website:

https://courses.cit.cornell.edu/ece315/

Homeworks

• Homeworks will be due on Thursdays at 7:00 PM in course drop box in Phillips Hall

• New homeworks and old homework solutions will appear on the course website by Thursday night

• Homework 1 will be due next Thursday and will be available on the course website by tomorrow night

Course Grading and Textbooks

• Course grading will be done as follows:
  - Homeworks and Labs (30%)
  - Midterm (30%)
  - Final Exam (35%)
  - Instructor discretion (5%)

• No in-class quizzes, no pop-quizzes, no clickers,

• Midterm and the Final exam will both be comprehensive

Textbooks

• There are no required textbooks. Highly recommended textbooks are:
  - Microelectronics: An Integrated Approach
    by Howe and Sodini (out of Print)
  - Microelectronic Devices and Circuits
    by Clifton Fonstad (out of print)
Course Recitation Sections

There will be recitation sections on MW 7:30-9:00 PM in PH219 almost every week

Goals: Homeworks, discussion, problem solving, etc

Course Labs

There will be labs on MTWRF 2:30-4:30 PM in PH237

There will be 4-5 labs total in the semester

Make sure you are signed up for one lab slot

Lab reports/writeups will be due the week following the lab

Goals: Characterize devices, build and test circuits

Labs are mandatory!

Course Staff

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TA office hours and locations: PH 429
(Times/days: Tuesdays/Thursdays 4:30-6:00 PM)
The computing ability per dollar has improved by ~5 orders of magnitude in the last 30 years.

The communication rate has improved by ~4 orders of magnitude in the last 30 years.
The Key Technology Driver: The Silicon Integrated Chip

A Memory chip from Nintendo Wii

(SEM) Copper interconnects in an IBM chip

Metal interconnects
The Key Technology Driver: The Silicon Integrated Chip

More than ~10 layers of metal interconnects in a 40 nm technology

The Key Technology Driver: The Silicon Transistor

22 nm gate Tri-gate Silicon transistors (INTEL)
The number of transistors in a dense integrated circuit doubles approximately every two years (Gordon E. Moore – 1965)

Benefits of Integration

Exponential improvements in:
1) System performance (speed)
2) Cost per function
3) Power per function
4) System reliability
Benefits of Integration

Clock Speed

Cost

Nano-Electronics

A single electron transistor (works on the principle of strong electrostatic repulsion between electrons in nanostructures)

A 45 nm gate MOS transistor (electrostatics become more important as device dimensions shrink)

A single atom transistor (Cornell)

Less than 100 atoms long!!

Gold leads

Single Atom

Gold leads
Nano-Photonics and Semiconductor Lasers

Light can be guided in integrated waveguides

Semiconductor laser chip

Wire bond

actual laser (the long strip)

fiber

RF-in
Nano-Photonics and Semiconductor Lasers

Nanopatch Plasmonic Lasers

Circular Nanopatch Laser: Radiation Pattern

Surface-normal emission

SNLs are optical versions of microwave patch antennas

Lasers on chip are becoming much smaller than the size of a photon!!

(Cornell, UCB)

Future of Integration: Electronics, Photonics, MEMs, Biology

Portable health monitoring (Terahertz, mm-wave, optics, sonic)
Semiconductors Taking Over: Solid State Lighting

Future of Integration: Electronics, Photonics, MEMs, Biology

IBM (Electronic/Opto-electronic Processors)
Flexible Displays

Flexible Internet Display Screen

Iphone (today)

Universal Display Corp.
Flexible, Pixelated, Display
Wireless (Micro Antennae)
Display (LEDs, Optoelectronics)
Transparency and Flexibility
Electronics (Graphene)

Or No Displays!

Scene from Star Wars (Fiction)

ICT Graphics Lab, USC (Reality)

Very Soon!

Wireless (Antenna)
Display (LEDs, Optoelectronics)
Electronics
Lasers (Hologram)