# DEPARTMENT OF ELECTRICAL ENGINEERING & COMPUTER SCIENCE

## CORE COURSES

### Semester I

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHM101</td>
<td>General Chemistry</td>
<td>3</td>
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<tr>
<td>MTH101</td>
<td>Calculus of One Variable</td>
<td>3</td>
</tr>
<tr>
<td>PHY101</td>
<td>Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>EES101</td>
<td>Introduction to Earth Sciences</td>
<td>3</td>
</tr>
<tr>
<td>CHE103</td>
<td>Engineering Design and Drawing</td>
<td>3</td>
</tr>
<tr>
<td>HSS101</td>
<td>English for Communication</td>
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<tr>
<td>PHY103</td>
<td>General Physics Laboratory – I</td>
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[| BIO101* or ECO101* | Biology I: Biomolecules or Principles of Economics – I | 3 |

Total Credits 21

### Semester II

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CHM112</td>
<td>Basic Organic Chemistry – I</td>
<td>3</td>
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<tr>
<td>MTH102</td>
<td>Linear Algebra</td>
<td>3</td>
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<tr>
<td>PHY102</td>
<td>Modern Physics</td>
<td>3</td>
</tr>
<tr>
<td>EES102</td>
<td>Introduction to Environmental Sciences</td>
<td>3</td>
</tr>
<tr>
<td>ECS102</td>
<td>Introduction to Programming</td>
<td>3</td>
</tr>
<tr>
<td>CHM114</td>
<td>Chemistry Laboratory – I</td>
<td>1</td>
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</tbody>
</table>

[| BIO102* or ECO102* | Biology II: Fundamentals of Cell Biology or Principles of Economics – II | 3 |

Total Credits 19

* BS (Engineering Sciences) students can take either BIO101 or ECO101 in their 1st semester, followed by BIO102 or ECO102, respectively in their 2nd semester. In other words, these students must either do both BIO101 and BIO102 in their 1st year, or both ECO101 and ECO102.

### Pre Major Year

#### Semester III

<table>
<thead>
<tr>
<th>Course No.</th>
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<tbody>
<tr>
<td>ECS201</td>
<td>Discrete Mathematics – I</td>
<td>3</td>
</tr>
<tr>
<td>ECS203</td>
<td>Basic Electronics</td>
<td>3</td>
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<tr>
<td>MTH201</td>
<td>Multivariable Calculus</td>
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[| *** **** Open Elective | 3 |
| *** **** Open Elective | 3 |
| *** **** Open Elective | 3 |

Total Credits 18

#### Semester IV

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<tbody>
<tr>
<td>ECS202</td>
<td>Data Structures and Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>ECS204</td>
<td>Signals and Systems</td>
<td>3</td>
</tr>
<tr>
<td>MTH202</td>
<td>Probability and Statistics</td>
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[| *** **** Open Elective | 3 |
| *** **** Open Elective | 3 |
| *** **** Open Elective | 3 |

Total Credits 18
## Professional Courses

### Semester V

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course Name</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ECS301</td>
<td>Principles of Communication</td>
<td>4</td>
</tr>
<tr>
<td>ECS307</td>
<td>Theory of Computation</td>
<td>4</td>
</tr>
<tr>
<td>ECS323</td>
<td>Control Systems</td>
<td>4</td>
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<tr>
<td>ECS325</td>
<td>Analog Circuits</td>
<td>4</td>
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<tr>
<td>ECS321</td>
<td>Electronic Devices</td>
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<tr>
<td>ECS327</td>
<td>EECS Laboratory I</td>
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### Semester VI

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<tbody>
<tr>
<td>ECS306</td>
<td>Algorithms</td>
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<tr>
<td>ECS322</td>
<td>Electromagnetic Theory</td>
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<tr>
<td>ECS326</td>
<td>Digital Circuits and Systems</td>
<td>4</td>
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<tr>
<td>ECS304</td>
<td>Data Science and Machine Learning</td>
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<tr>
<td>ECS330</td>
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<tr>
<td>ECS409</td>
<td>Computer Organization</td>
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<tr>
<td>ECS ***</td>
<td>Departmental Elective – I</td>
<td>4</td>
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<tr>
<td>ECS ***</td>
<td>Departmental Elective – II</td>
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### Semester VIII

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<tbody>
<tr>
<td>ECS408</td>
<td>Operating Systems</td>
<td>4</td>
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<tr>
<td>ECS 412</td>
<td>Project Work</td>
<td>4</td>
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<tr>
<td>ECS ***</td>
<td>Departmental Elective – III</td>
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<tr>
<td>*** ***</td>
<td>Open Elective – III</td>
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<td><strong>Total Credits</strong></td>
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Curriculum for additional one year to obtain BS-MS (Dual Degree) in EECS

### Semester IX

<table>
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<tr>
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<tr>
<td>ECS 501</td>
<td>MS Thesis</td>
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<tr>
<td>*** ***</td>
<td>Open Elective – V</td>
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<tr>
<td>*** ***</td>
<td>Open Elective – VII</td>
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<tr>
<td>HSS 503(^5)</td>
<td>Law Relating to Intellectual Property and Patents</td>
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<td><strong>Total Credits</strong></td>
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### Semester X

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<th>Credits</th>
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<tbody>
<tr>
<td>ECS 502</td>
<td>MS Thesis</td>
<td>18</td>
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</tbody>
</table>

\(^5\)Students can credit this course any time before completion of BS Programme, as and when offered.
List of mandatory courses required to be credited in order to get a Minor in EECS

<table>
<thead>
<tr>
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<tbody>
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</tr>
<tr>
<td>ECS202</td>
<td>Data Structures and Algorithms</td>
<td>3</td>
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<tr>
<td>ECS203</td>
<td>Basic Electronics</td>
<td>3</td>
</tr>
<tr>
<td>ECS204</td>
<td>Signals and Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECS301</td>
<td>Principles of Communication</td>
<td>4</td>
</tr>
<tr>
<td>ECS409</td>
<td>Computer Organization</td>
<td>4</td>
</tr>
</tbody>
</table>
ECS 102: Introduction to Programming (3)

Course Content

- Data types, Variables, Identifiers.
- Variable declaration, Assignment statement.
- Input/output, Comments.
- Operators and Expressions.
- Conditional expressions. Conditional statements: if-then, if-then-else, nested conditionals, switch-case.
- Loops: for, while, repeat.
- Arrays, multi-dimensional arrays.
- Functions. Recursion.
- Pointers. Memory and its management.
- Structures. Data Structures.

References

2. Programming in ANSI C by Balaguruswamy.
3. The C Programming Language by Kernighan and Ritchie, Prentice-Hall India. (This is a standard reference to C. Slightly advanced though.)

ECS 201: Discrete Mathematics I (3)

Course Content

- Mathematical proofs, proofs by induction, by contradiction, proving the contrapositive.
- Basic counting techniques, pigeon-hole principle, recurrence relations, generating functions, principle of inclusion and exclusion, Mobius inversion.
- Some other topics from combinatorics and graph theory.
References


ECS 203: Basic Electronics (3)

Course Objectives
The objective of this course is to impart basic background in analog and digital circuits. The course would use simple models; detailed description of the semiconductor devices would be covered in a separate course. The internal circuits of the blocks used in this course (such as op-amps, logic gates) will not be covered in this course. Instead, the broad behavioral description of these blocks will be used to explain the circuit operation.

Course Content

- Thevenin's theorem
- RC circuits (single capacitor)
- Diodes and diode circuits (finding $V_o$-$V_i$ relation,
- clipper, peak detector, clamper, voltage doubler)
- Zener diodes and voltage limiter circuit
- Half-wave and full-wave rectifier circuits
- BJT: basic functionality
- BJT common-emitter amplifier in the mid-band region
  (frequency response not covered)
- Introduction to op-amps
- Analysis of op-amp circuits in the linear region
- Inverting/non-inverting amplifier, summer integrator
- Schmitt trigger
  oscillator based on Schmitt trigger
- Boolean logic
- Basic digital gates and truth tables
- function minimisation using Karnaugh maps
- Combinatorial circuit blocks
  (MUX, DEMUX, encoders, decoders)
- introduction to sequential circuits
- NAND and NOR latch
- flip-flops
- shift registers and counters
- review of DAC and ADC

Suggested Lab Experiments:
- diode clipper/clamper/voltage doubler
- BJT common-emitter amplifier
- op-amp circuits: inverting/non-inverting amplifiers
  integrator, summer
- op-amp circuits: oscillator based on Schmitt trigger
- binary counter
- synchronous counter

References

ECS 202: Data Structures and Algorithms (4)

Course Content
- Random-access-machine model, concept of problem size, and asymptotic behaviour of time/space complexity.
- Estimation of time/space complexity by smooth functions and order notations.
- A simple example of worst-case time/space complexity analysis.
• Elementary data-structures: arrays, lists, queues, stacks and their applications.
• Binary search algorithm, binary trees, binary-search-tree data-structure.
• Balanced binary-search-tree: Red-Black trees.
• Hashing for insert, search, delete.
• Heap data structure.
• Efficient data structures, apart from those listed above, for sets with the following group of operations:
  ✓ insert, delete, membership
  ✓ insert, delete, minimum
  ✓ union, intersection, difference
  ✓ disjoint-set union
• Sorting algorithms, including the average case analysis of quick-sort.
• Greedy paradigm with examples.
• Divide and conquer paradigm with examples.
• Dynamic-programming paradigm with examples.
• Definition of graphs, paths, trees, cycles. Data structures for graphs: adjacency lists, adjacency matrix.
• Graph algorithms: Depth First Search, Breadth First Search, Minimum Spanning Tree.

References

ECS 204: Introduction to Signal Processing and Systems (3)

Course Content
Introduction to the Course and Basic Concepts; Signals & their Transformation; Elementary Signals in the Continuous and Discrete Time Domains; Classification of Systems; Properties of Linear Time Invariant Systems; Convolution, Invertibility, Stability and Causality; Unit Step and Impulse Responses; Systems Described by Differential & Difference Equations; Fourier Series; Introduction to Fourier Transform for Continuous Time signals; Fourier Transform of Periodic Functions; Fourier Transform Properties; Fourier Analysis of Discrete Time Signals & Systems; Properties of DTFT; Convolution, Modulation & Other Properties of DTFT; Introduction to Sampling; Spectrum of Sampled Signals, Aliasing; Introduction to Laplace Transform; Properties of Laplace Transform; Introduction to Z Transform; Properties of Z Transform.

References

ECS 301: Principles of Communications (4)

Course Content
This course includes the following contents:

- Introduction: Signal and Spectra
- Amplitude Modulation Systems
- Angle Modulation
- Pulse Modulation and Digital Transmission of Analog Signals
- Digital Modulation and Transmission
- Random Variables and Processes
- Mathematical Representation of Noise
- AM Reception Performance Under Noise
- FM Reception Performance Under Noise
- Phase Locked Loops
- Optimal Reception of Digital Signal
- Noise in Pulse Code Modulation and Delta Modulation Systems
- Information Theoretic Approach to Communication
- Error-Control Coding
Communication Systems and Component Noises
• Spread Spectrum Modulation
• Miscellaneous Topics in Communication Systems

References:
1. Principles of Communication Systems (SIE) 4E Paperback – 1 Jul 2013 by Herbut Taub (Author), Donald L. Schilling (Author), Goutam Saha (Author)

ECS 307: Discrete Mathematics I (4)

Course Content
• Mathematical proofs, proofs by induction, by contradiction, proving the contrapositive.
• Basic counting techniques, pigeon-hole principle, recurrence relations, generating functions, principle of inclusion and exclusion, Mobius inversion.
• Graphs, trees - definitions. Connectivity, paths, cycles, Eulerian walks, Hamiltonian cycles, cliques, colourings, graph matching, planarity.
• Discrete probability. Sample space, events, probability - basic laws, discrete random variable, expectation, linearity of expectation, independence, conditioning, Bayes theorem, Bernoulli, binomial and geometric distributions, moments and deviations, Markov, Chebyshev inequalities, Chernoff bounds.
• Application of probabilistic methods in combinatorics and graph theory.

Books and References
ECS 303: Computer Organization (4)

Course Content

- Introduction.
- Arithmetic algorithms.
  - Overview of basic digital building blocks; truth tables; basic structure of a digital computer.
  - Number representation: Integer - unsigned, signed (sign magnitude, 1’s complement, 2’s complement); Characters - ASCII coding, other coding schemes; Real numbers - fixed and floating point, IEEE754 representation.
  - Basic building blocks for the ALU: Adder, Subtractor, Shifter, Multiplication and division circuits.
- Hardware description language. Introduction to some HDL (Verilog, VHDL, BSV). Digital Design using HDLs.
- CPU.
  - CPU Sub-block: Datapath - ALU, Registers, Instructions, Execution of Instructions; CPU buses; Control path - microprogramming, hardwired logic; External interface.
  - Examples of some well known processors.
- Assembly Language Programming. Instruction set and Assembly programming for some processor, preferably the one described in class.
- Memory.
  - Memory Sub-block: Memory organization; Technologies - ROM, RAM, EPROM, Flash, etc., Virtual Memories.
  - Cache: Cache algorithms, Cache Hierarchy, Cache coherence protocols.
  - Advanced concepts: Performance, Interleaving, On chip vs Off chip Memories/Caches.
- I/O and Peripherals.
  - I/O Sub-block: I/O techniques - interrupts, polling, DMA; Synchronous vs. Asynchronous I/O; Controllers.
  - Peripherals: Keyboard, Mouse, Monitors, Disk drives, etc.
Lab Contents.

- Digital Design using HDLs. Simple circuit designs: For e.g. Counter, Multiplexer, Arithmetic circuits etc. Design of a Simple Processor: Includes register file, ALU, data paths.
- FPGA Programming Programming on Xilinx Spartan 3E (or equivalent) FPGA. Handling of Inputs: through slide switches, through push buttons. Handling of Outputs: 7-segment display, LED display, LCD display. The designs developed in Part-I can be used to program the FPGA.
- Assembly Language Programming Programming in assembly language. The assignments should cover the following concepts: Registers; different type of instructions (load, store, arithmetic, logic, branch); operand addressing modes; memory addressing modes; conditions (codes/flags and conditional branches) stack manipulation; procedure calls; procedure call conventions (load/store of; arguments on stack, activation records);

Books and References

8. Books related to HDL (Verilog, VHDL, BSV) programming.
**ECS 321: Electronic Devices (4)**

**Course Content**

The purpose of this course is to provide a background in basic semiconductor physics and semiconductor devices. This background would help the student to appreciate the main features of the devices covered in the course.

In the lab experiments, students will be able to make measurements and relate those with the concepts covered in the theory part.

**Topics:**

- carrier statistics, mobility, drift and diffusion
- Poisson's equation and continuity equation
- p-n junction in forward bias and reverse bias
- I-V curve for a p-n junction
- capacitance of a p-n junction under reverse bias
- turn-off transient for a p-n junction
- basic operation of a solar cell
- metal-semiconductor junction (I-V curve)
- BJT Ebers-Moll model
- BJT $I_c-V_{cc}$ curve
- BJT small-signal model
- JFET: principle of operation and I-V
- MOS capacitor, C-V at low and high frequencies
- MOS transistor

**Suggested Lab Experiments:**

- measurement of diode I-V curve
  (need to use a current source for measurements in the forward bias range)
- turn-off transient for a diode
- measurement of $I_c-V_{cc}$ of a BJT for different $I_b$ values
- measurement of $I_d-V_{ds}$ for a MOS transistor with different $V_{gs}$ values and $I_d-V_{gs}$ for two $V_{ds}$ values

**References**


3. Modular Series on Solid State Devices


**ECS 325: Analog Circuits (4)**

**Course Content**

This course serves as an extension of the basic electronics course in the analog circuit domain. Advanced concepts such as feedback, current sources, non-idealities in op-amps will be covered.

**Topics:**
- difference amplifier
- current sources and active loads
- output stages
- internal circuit of op-amp 741
- feedback configurations with examples
- frequency response of amplifiers
- stability of amplifiers
- Bode plots
- op-amp filters
- instrumentation and isolation amplifiers
- precision rectifiers
- logarithmic amplifiers
- non-idealities in op-amps: offset voltage and bias currents
- effect of op-amp non-idealities in circuits
- sinusoidal oscillators
- sample-and-hold circuits
- introduction to CMOS analog circuits

References


ECS 326: Digital Circuits and Systems (4)

Course Content

The purpose of this course is to familiarise the student with basic features of logic gates and also give sufficient exposure to modern digital components such as FPGA. Some home-work assignments based on a hardware description language would be helpful.

Topics:
- overview of logic families
- definition of noise margin
- CMOS inverter and other gates
- binary number system
- digital arithmetic
- finite state machine design, analysis, and synthesis
- introduction to hardware description languages
- array-based logic elements (memory, PLA, FPGA)
- special topics (e.g., processor design, test and verification)

References

ECS 328: Communication Systems(4)

Course Content

- Introduction
- Analog Vs. Digital Communication Systems
- A General Communication System, Some Probability Theory, Probability space, random variables, density functions, independence, Expectation, conditional expectation, Baye’s rule, Stochastic processes, autocorrelation function, stationarity, spectral density
- Analog-to-digital conversion, Sampling (ideal, natural, sample-and-hold), Quantization, PCM.
- Source coding (data compression), Measuring information, entropy, the source coding theorem, Huffman coding, Run-length coding, Lempel-Ziv.
- Communication channels, Bandlimited channels, The AWGN channel, fading channels
- Receiver design, General binary and M-ary signaling, Maximum-likelihood receivers Performance in an AWGN channel. The Chernoff and union/Chernoff bounds, Simulation techniques
- Signal spaces
- Modulation: PAM, QAM, PSK, DPSK, coherent FSK, incoherent FSK
- Channel coding, Block codes, hard and soft-decision decoding, performance Convolutional codes, the Viterbi algorithm, performance bounds, Trellis-coded modulation (TCM), Signaling through bandlimited channels ISI, Nyquist pulses, sequence estimation, partial response signaling, Equalization Signaling through fading channels, Rayleigh fading, optimum receiver, performance Interleaving Synchronization, Symbol synchronization, Frame synchronization Carrier synchronization

References:

**ECS 322: Electromagnetic Theory (4)**

**Course Content**

- Basic concepts of electrostatics, electric potential theory, electric fields and currents, fields of moving charge, magnetic fields, time varying electromagnetic fields, Maxwell’s equations. Review of Maxwell’s equations, uniform plane waves in different types of media, reflection, and transmission of uniform plane waves, transmission lines, waveguides, and antennas.
- Coulomb's law and electric fields
- Gauss's law, potential and energy, conductors and dielectrics
- Laplace and Poisson equations, solution methods, and capacitance
- Biot-Savart and Ampere's laws, inductance calculation
- Magnetic materials, Faraday's law and quasi-static analysis
- Maxwell equations and uniform plane waves
- Wave propagation in dielectrics and conductors, skin effect, normal incidence
- Oblique incidence, Snell's law, and total internal reflection
- Transmission lines, Smith chart, impedance matching
- Transients and pulse propagation on transmission line
- Waveguides: Metallic and Dielectric
- Antenna fundamentals

**References**


**ECS 323: Control Systems (4)**

**Course Content**

To understand the essentials of mathematical system modeling; to be able to assess stability and performance properties of linear systems, and be able to design lead and lag controllers for linear systems using s-domain and frequency domain techniques.

**References**

1. Modern Control Engineering, 5th edition by Katsuhiko Ogata
ECS 324: Digital Signal Processing (4)

Course Content

An understanding of digital signal processing fundamentals and techniques is essential for anyone whose work is concerned with signal processing applications. This course introduces the basic concepts and principles underlying discrete-time signal processing. Concepts will be illustrated using examples of standard technologies and algorithms.

Topics covered include:

- Sampling and multi-rate systems
- Oversampling and quantization in A-to-D conversion
- Properties of LTI systems
- Digital filter design
- Discrete Fourier Transform and FFT
- Parametric signal modeling
- Applications in speech/audio processing, autonomous vehicles and software radio

References

1. Digital Signal Processing by A.V. Oppenheim and R.W. Schafer

ECS 305: Discrete Mathematics II (4)

Course Content

Modular first half: Abstract algebra

- Group theory: definition of groups, cosets and Lagrange’s theorem, subgroups, normal subgroups, quotient groups, group action and Burnside’s lemma.
- Rings, Fields, integral domains - basic definitions and properties. Field extensions, Chinese remaindering over integers and polynomial rings. (optional: Introduction to finite fields)

Modular second half: Logic

- Propositional logic syntax and semantics.
- Tautologies, axiom system and deduction.
- Proof of soundness and completeness.
First order logic syntax and semantics.
Structures, models, satisfaction and validity.
Axiomatization, soundness and completeness.
Optional: some advanced topics.

Books and References:

ECS 306: Algorithms (4)

Course Content
- Amortized analysis.
- Exposure to some advanced data structures (For example, Fibonacci heaps or augmented data structures or interval trees or dynamic trees).
- As part of the course on Data Structures and Algorithms, three algorithm paradigms, namely, greedy method, divide and conquer, and dynamic programming are discussed. These algorithm paradigms should be revisited in this course, but with advanced applications and/or emphasis on their theoretical foundations as follows:
  - Greedy method: theoretical foundations of greedy method (matroids) and other applications.
  - Divide and Conquer: FFT algorithm and other applications.
  - Dynamic Programming: Bellman Ford algorithm and other applications.
- Graph algorithms: all-pairs shortest paths, bi-connected components in undirected graphs, strongly connected components in directed graphs, and other problems.
- Pattern matching algorithms.
- Lower bound on sorting.
- Algorithms for maximum flow and applications.
• Notion of intractability: NP-completeness, reduction (the proof of Cook-Levin theorem may be skipped)
• Exposure to some (one or more) topics from the following list:
  ✓ Approximation algorithms.
  ✓ Algebraic and number theoretic algorithms.
  ✓ Computational Geometry.
  ✓ Linear programming.
  ✓ Parallel/distributed algorithms.
  ✓ Randomized algorithms.

Books and References

ECS 307: Theory of Computation (4)

Course Content
• Introduction: Motivation for studying theory of computation, a quick overview of the subject. Notion of formal language. Language membership problem, why this is taken as the central problem of the subject.
• Finite automata and regular expressions: DFA, NFA (with and without transitions), their equivalence. Proof that for some languages NFAs can be exponentially more succinct than DFAs. Definition of regular expressions. Proof that FAs recognize, and regular expressions denote the same class of languages, viz., regular languages.
• Properties of regular languages: Pumping lemma and its use to prove non-regularity of a language, closure properties of class of regular languages, decision properties: converting among representations, testing emptiness, etc. Minimization of DFAs, Myhill-Nerode theorem.
• Context-free grammars and languages: Derivation, parse trees. Language generated by a CFG. Eliminating useless symbols, \-productions, unit productions. Chomsky normal form.

• Pushdown automata: Definition, instantaneous description as a snapshot of PDA computation, notion of acceptance for PDAs: acceptance by null states, and by empty stack; the equivalence of the two notions. Proof that CFGs generate the same class of languages that PDAs accept.

• Properties of context-free languages: Pumping lemma for context-free languages and its use to prove a language to be not context-free. Closure properties of the class of context-free languages. CYK algorithm for CFL membership, testing emptiness of CFLs.

• Turing machines: Historical context, informal proofs of undecidability. Definition of TM, instantaneous description as a snapshot of TM computation, notion of acceptance. Robustness of the model: both natural generalizations and restrictions keep the class of languages accepted invariant. (Generalizations: multi-track, multi-tape, nondeterministic, etc. Restrictions: semi-infinite tape, counter machines). Church-Turing hypothesis.

• Undecidability: Definitions of r.e. and recursive languages. Turing machine codes, the diagonalization language and proof that it is not r.e. Universal Turing machine. Universal language, its semi-decidability. Reducibility and its use in proving undecidability. Rices theorem. Undecidability of Posts correspondence problem.

• Intractability: Motivation for the notion. The class P as consensus class of tractable sets. Classes NP, co-NP. Polynomial time reductions. NP-completeness, NP-hardness. Cook- Levin theorem. Mention about boundary of tractability: 2SAT vs. 3SAT, 2D matching vs. 3D matching. Some NP-completeness proofs: vertex cover, clique, independent sets, Hamiltonian graphs, subset-sum, set cover.

Books and References


ECS 302: Operating Systems (4)

Course Content

- Introduction: review of computer organization, introduction to popular operating systems like UNIX, Windows, etc., OS structure, system calls, functions of OS, evolution of OSs.
- Computer organization interface: using interrupt handler to pass control between a running program and OS.
- Concept of a process: states, operations with examples from UNIX (fork, exec) and/or Windows. Process scheduling, interprocess communication (shared memory and message passing), UNIX signals.
- Threads: multithreaded model, scheduler activations, examples of threaded programs.
- Scheduling: multi-programming and time sharing, scheduling algorithms, multiprocessor scheduling, thread scheduling (examples using POSIX threads).
- Process synchronization: critical sections, classical two process and n-process solutions, hardware primitives for synchronization, semaphores, monitors, classical problems in synchronization (producer-consumer, readers-writer, dining philosophers, etc.).
- Deadlocks: modeling, characteristics, prevention and avoidance, detection and recovery.
- Memory management: with and without swapping, paging and segmentation, demand paging, virtual memory, page replacement algorithms, working set model, implementations from operating systems such as UNIX, Windows. Current Hardware support for paging: e.g., Pentium/ MIPS processor etc.
- Secondary storage and Input/Output: device controllers and device drivers, disks, scheduling algorithms, file systems, directory structure, device controllers and device drivers, disks, disk space management, disk scheduling, NFS, RAID, other devices. operations on them, UNIX FS, UFS protection and security, NFS.
Protection and security: Illustrations of security model of UNIX and other OSs. Examples of attacks.

Epilogue: Pointers to advanced topics (distributed OS, multimedia OS, embedded OS, real-time OS, OS for multiprocessor machines).

All the above topics will be illustrated using UNIX and/or Windows as case-studies. The lectures will be supplemented by a set of assignments/projects on an instructional operating system. This is the lab component.

Books and References


ECS 304: Introduction to Data Science and Machine Learning (4)

Course Content

- Introduction to Data Science
- Big data technologies
- Information management in Big Data and Emerging Issues
- Supervised Learning Algorithms:
  - Logistic Regression
  - Neural Networks
  - Decision Trees
  - Nearest Neighbour
  - Support Vector Machines
  - Naïve Bayes
- ML and MAP estimates
- Bayes’ Optimal Classifier
- Introduction to Graphical Models
- Generative Vs. Discriminative Models
Unsupervised learning algorithms:
  o K-Means clustering
  o Expectation Maximization
  o Gaussian Mixture Models
  o PCA and Feature Selection
  o PAC Learnability
  o Reinforcement Learning

**List of Departmental Electives**

**CSE**
1. Randomized Algorithms
2. Approximation Algorithms
3. Combinatorial Optimization
4. Computational Complexity
5. The Graph Isomorphism Problem
6. Introduction to Software Modeling and Verification
7. Advanced Model Checking
8. Stochastic Model Checking
9. An Introduction to Petri Nets
10. Concurrency theory
11. Introduction to Cyber Physical Systems

**ECE**
1. Solid State Devices
2. Nanoelectronics: Fundamentals and Applications (includes emerging nanoelectronics)
3. Advanced Solid State Devices
4. Nanoscale Transistors
5. Electronic Transport in Semiconductors
6. Spin Transport (Non-Equilibrium Green's function based formalism, spin diffusion, spin pumping etc.)
7. Spintronics and Nanomagnetics
8. Nonlinear systems
9. Plasma and Plasmonics
10. Analog integrated circuits
11. Digital integrated circuits
12. Compact modeling of transistors
13. Integrated circuit device modeling and simulation
14. Random processes