



## Underground Tutor

# Background for Success at Cambridge University Engineering Department

September, 2003  
Version 1.7

# Typical 3<sup>rd</sup> Year Modules that EE Students Take (Engineering Tripos Part IIA)

- Michaelmas (1<sup>st</sup> Term)

- 3B1 Radio Frequency Electronics**

- 3B3 Switch-Mode Electronics**

- 3B5 Semiconductor Engineering**

- 3F1 Signals and Systems**

- 3F3 Signal and Pattern Processing**

- 3F5 Computer and Network Systems**

- 3I1 Data Structures and Algorithms**

- Lent (2<sup>nd</sup> Term)

- 3B2 Integrated Digital Electronics**

- 3B4 Electric Drive Systems**

- 3B6 Photonic Technology**

- 3F2 Systems and Control**

- 3F4 Data Transmission**

- 3F6 Software Engineering and Design**

# 3B1: Radio Frequency Electronics

- **MIT pre-requisites**
  - 6.012 and/or 6.101 helps but not required
- **MIT equivalence and topics covered**
  - Second half + (circuits part) of 6.012, plus some 6.301
  - Every component found in a superhet: transistor amplifier, oscillator, mixers, filters
  - impedance matching using Smith Charts.
- **Teaching style and quality**
  - Presents example circuits where component values need to be chosen
  - Need to appreciate or at least tolerate  $\pi = 3 = e$  (black magic)
  - Important to memorize some circuits presented (won't be given on exam...must recreate)
- **Difficulty/Challenges**
  - Don't let Cambridge students who have seen some amplifiers before intimidate you!
- **Exam strategy**
  - Be able to derive all equations for every circuit presented in lecture
  - Understanding the rationale behind the rules of thumb is important for application, but not essential. Just makes life easier.
- **Resources**
  - Lecture Notes
- **Assumed background and holes to plug**
  - Basic transistor amplifier
  - Bipolar, JFET and other transistor models

# 3B2: Integrated Digital Electronics

- **MIT pre-requisites**
  - 6.002
- **MIT equivalence and topics covered**
  - About first half of 6.004
  - Combinational logic; programmable logic arrays
- **Teaching style and quality**
- **Difficulty/Challenges**
- **Exam strategy**
- **Resources**
- **Assumed background and holes to plug**
  - None

# 3B3: Switch Mode Electronics

- **MIT pre-requisites**
  - 6.101 helps but not required
- **MIT equivalence and topics covered**
  - Basic concepts of 6.334
  - AC-DC, DC-DC, DC-AC converters, PWM, H-Bridges, rectifiers, three phase, thyristors.
- **Teaching style and quality**
  - Presents example circuits and analyzes the functionality
- **Difficulty/Challenges**
  - Don't let Cambridge students intimidate you!
- **Exam strategy**
  - Be able to derive all equations for every circuit presented in lecture.
  - Resonance & resonant converters
- **Resources**
  - Mohan and lecture notes
- **Assumed background and holes to plug**
  - Three phase rectifiers, etc.
  - Thyristor

# 3B4: Electric Drive Systems

- **Important Message: Do not take this module unless really interested. Take 3B3 instead.**
- **MIT pre-requisites**
  - Have experience with motors; both physical (e.g. some of 6.013) and equivalent circuits (only covered in some MIT grad classes)
- **MIT equivalence and topics covered**
  - None really.
- **Teaching style and quality**
  - Teaching okay but will spend all your time catching up on earlier material
  - Terminology gap
- **Exam strategy**
  - Old exams, mostly the same every year
- **Resources**
  - Three books, Electric Drive Systems, Power Electronics (Mohan), Electric Power Systems (Weedy)
- **Assumed background and holes to plug**
  - Terminology, familiarity with material not taught in MIT undergrad subjects

# 3B5: Semiconductor Engineering

- **MIT pre-requisites**
  - Need 6.002, 8.02
  - 3.091 or 5.112 helps but not required
  - Math not too bad; they provide what's needed
- **MIT equivalence**
  - First 2/3 (devices part) of 6.012. Emphasizes energy band concepts more than 6.012 does.
- **Teaching style and quality**
  - Many derivations and proofs; emphasizes memorization
  - Most people found this generally interesting and worthwhile
- **Difficulty/Challenges**
  - 1<sup>st</sup> two weeks very fast run through of quantum physics; memorization/exposure rather than deep understanding (too fast) – some early exposure would help; CUED students in similar boat
  - 2<sup>nd</sup> half more applied and difficult
- **Exam strategy**
  - heavy on memorization/understanding of the notes; additional reading needed to understand
- **Resources**
  - Flewitt notes and supervisions are very good; 2<sup>nd</sup> half okay but not as good
  - Streetman is key text; lecture notes draw from additional texts
- **Assumed background and holes to plug**
  - Basic physics and chemistry
  - Bipolar, JFET and other transistors; structure and differences assumed (exposure)

# 3B6: Photonic Technology

- **MIT pre-requisites**
  - 8.02, 6.002; 3B5
- **MIT equivalence and topics covered**
  - Optoelectronic devices; photonic systems and applications
  - no clear undergraduate MIT equivalent
- **Teaching style and quality**
  - Interesting course overall
  - Chris Morgan an excellent supervisor
- **Difficulty/Challenges**
  - Must come up with own estimates/rules of thumb with no or limited experience
  - Take knowledge from 3B5 and go further in applying to real circuits
- **Exam strategy**
- **Assumed background and holes to plug**
  - none

# 3F1: Signals and Systems

- **MIT pre-requisites**
  - First half of 6.003 – continuous time systems and transforms
  - 6.041 or 6.042 helpful but not essential for probability
- **MIT equivalence and topics covered**
  - 6.003 and parts of 6.011 (if have 6.003 can potentially skip this module)
- **Teaching style and quality**
  - Notes not very clear on random processes
  - Christopher Kemp especially good at supervisions
- **Difficulty/Challenges**
  - 1<sup>st</sup> part hard; 2/3<sup>rd</sup> parts flow better
  - If you haven't had 6.003, you definitely need to study ahead before getting to CU
- **Exam strategy**
  - Emphasizes power spectral density, autocorrelation, covariance
- **Resources**
  - Key Texts: Dorf, Modern Control; Oppenheim & Willsky
- **Assumed background and holes to plug**
  - Continuous time transforms – Fourier & Laplace transforms assumed
  - Random processes & probability assumed; pmf, pdf, cdf, Bayes Rule
  - Nyquist stability diagrams & criterion; CU students had seen before
  - Gain and phase margins

# 3F2: Systems and Control

- **MIT pre-requisites**
  - 18.06 (linear algebra) helpful
- **MIT equivalence and topics covered**
  - 6.011 control material; state space methods for modeling and analyzing dynamic systems; state estimation; state observer combined with state feedback
- **Teaching style and quality**
  - One of the few where students from multiple disciplines are taking the subject at the same time – shows that this subject matter is relevant and important in many areas
- **Difficulty/Challenges**
  - Challenging but most found this interesting
- **Exam strategy**
- **Resources**
  - Texts: Dorf; Franklin, Powell, & Emani-Naeini
- **Assumed background and holes to plug**
  - Matrix manipulation and eigenvalue properties (MIT online lectures helpful)
  - Assumes good understanding of continuous time transfer functions, poles/zeros, frequency response, etc; this is NOT reviewed in 3F1 since assumed people had already in 2<sup>nd</sup> year

# 3F3: Signal and Pattern Recognition

- Michaelmas term; assumes taking 3F1 also (or 6.011 before)
- **MIT pre-requisites**
  - 6.041 essential
  - Math for digital filters: linear algebra & matrix calculus (e.g. differentiating in matrix notation)
- **MIT equivalence and topics covered**
  - 6.034 and stochastics in 6.011
- **Teaching style and quality**
  - 1<sup>st</sup> lectures: perceptron/NN – but mathematically
  - 2<sup>nd</sup> lectures: digital filters, FFT
  - Last lectures: filters, AR, random processes & Wiener filters (some timing issues w.r.t. 3F1)
  - Sub-modules taught by different faculty; little transition/integration across materials or faculty
- **Exam Strategy and Hints**
  - Bilinear transform!
  - FFT (need to know derivation/proof), ARMA
  - Multivariate gaussians (need this, not on Data Books)
  - Data books – knowing what is in them very helpful (e.g. after you've studied)
- **Resources/References**
  - Lecture Notes: Last part good; rest are okay
  - Books are hard to find for this class (not in library)
  - Useful to study together (to understand concepts)
- **Assumed background and holes to plug**
  - Digital filter design – some basics; Saturation; overflows, resolution/quantization, filter scaling rules
  - Data representation (hardware 6.004 stuff)
  - matrix calculus (e.g. differentiating in matrix notation)

# 3F4: Data Transmission

- **MIT pre-requisites**
  - 6.041; 6.003; 6.011 or alternatively take 3F1 and 3F3
- **MIT equivalence and topics covered**
  - Parts of 6.450;
  - Topics Include:
    - i.) 1<sup>st</sup> Half: ISI; SNR; Line Coding; Block Codes; Equalization Filters; Bit Error Rate transmit/receive filters;
    - ii.) 2<sup>nd</sup> Half: Phasors; PSK, QPSK, QAM, BPSK; Brief lectures on digital TV operation
- **Difficulty/Challenges**
  - Final Exam was one of the more challenging (medium hard – hard).
  - Recommended texts for class are poor reference materials. 1<sup>st</sup> half of course is relatively easy to grasp. However, second half of course ramps up in difficulty. Both lecturers are dry and boring making sitting through lectures difficult.
- **Teaching style and quality**
  - Useful handouts and lecture notes distributed
  - Both lecturers tend to read off the lecture notes, regurgitating the same information.
- **Exam strategy**
  - Go through as many practice exams as possible.
  - Focus on understanding the 1<sup>st</sup> half of the material really well first before proceeding to study for the 2<sup>nd</sup> half. Questions on the 1<sup>st</sup> half tended to be easier.
- **Assumed background and holes to plug**
  - Make sure you have a good grasp of the recommended MIT pre-requisites. They contain the extent of the assumed background.

# 3F5: Computer and Network Systems

- **MIT pre-requisites**
  - No essential pre-reqs
- **MIT equivalence and topics covered**
  - 6.033
  - Networks part: switching/OSI model, LAN, TCP/IP.
  - Computer systems part: architecture, instruction sets, alu design, datapath/control, pipelining; caches and virtual memory; I/O; operating systems
- **Teaching style and quality**
  - Network section focuses on protocols and standards which are not very interesting
- **Difficulty/Challenges**
- **Exam strategy**
  - Tripos questions actually ask to apply material from the notes; the examples papers (on network part) do not do this very well
- **Resources**
  - Tanenbaum; long list of books in library
- **Assumed background and holes to plug**
  - none

# 3F6: Software Engineering and Design

- **MIT pre-requisites**
  - None; Basic C++ knowledge (enough to be able to read code)
- **MIT equivalence and topics covered**
  - Perhaps a non-coding version of 6.170
  - Design Patterns
  - Understanding of Object Orientated Programming
  - Distributed Systems: implementing client – server programs through CORBA
  - Software Design Process – methodologies; what to and what not to do in the process
  - Concurrent Systems – monitors, semaphores, etc.
- **Teaching style and quality**
  - Lecturers are both well-spoken
  - Interesting lectures; excellent lecture notes. (They're more or less all you'll need)
  - Georg Klein an especially good supervisor
- **Difficulty/Challenges**
  - One of the easier courses; However, although the course during the year seemed really easy, don't get complacent. The final exam was actually harder then most expected. It was fair though and in terms of difficulty I would rank it as average.
  - Useful to study together (to understand concepts)
  - If you have a good memory, it will serve you well for the second half of the course which focuses on the Software Design Process and requires substantial memorization
- **Exam strategy**
  - Just go over the exam questions and you'll be fine.
- **Assumed background and holes to plug**
  - Take some time and learn a little bit of C++ using the 2<sup>nd</sup> year review book on C++. (You can get this for free at the DPO)

# 3I1: Data Structures and Algorithms

- **MIT pre-requisites**
  - C++ helpful
  - 6.042 discrete mathematics/probability important
- **MIT equivalence and topics covered**
  - Parts of 6.046 (algorithms)
- **Teaching style and quality**
  - Packet of notes (good), which lecturer goes through. Important to go to lecture to know what he goes into more detail on and emphasizes.
  - Not coding based – more knowing how things would work, orders of growth analysis
  - No labs for this module
  - Particularly useful to study together to understand algorithms
  - Taught by Computer Lab faculty at Engineering Department
- **Difficulty/Challenges**
- **Exam Strategy**
  - **Challenging.** Little previously existing material in archives (example exams). Can't get cribs to past exams (Computer Lab policy)
- **Resources**
  - Booklet on C++ available; condensed version of what CUED 1<sup>st</sup> & 2<sup>nd</sup> year did
  - Cormen text very helpful
- **Assumed background and holes to plug**

## Possible 4<sup>th</sup> Year Modules

- 4F12 – Computer Vision and Robotics
- 4M12 – Complex Analysis and Variational Methods
- 4F6 – Signal Detection and Estimation
- Any other math course
  
- DO NOT TAKE 4F2 (Multivariable Robust Control)



# Taking Classes at the Computer Laboratory

- At Cambridge, CS and EE are in two independent departments with their own curriculum, schedules, etc.
- You **CAN** take Computer Science classes at the Computer Lab in addition to your engineering curriculum.
- There are a number of classes, seminars, and projects offered, including lots of Microsoft-sponsored seminars (and tons of free food).
- **Reasons to do this:**
  - Broaden your Cambridge experience – meet more people, faculty, take a balanced range of classes
  - Great for 6.2's who would like to take CS classes in addition to EE

# Computer Lab Offerings

- Some Classes Offered:

- Complexity Theory
- Computation Theory
- Computer Graphics and Image Processing
- Digital Communication
- Introduction to Functional Programming
- Introduction to Security
- Natural Language Processing
- Numerical Analysis II
- Artificial Intelligence I
- Business Studies
- Databases
- Distributed Systems

- Computer Design
- Continuous Mathematics
- Data Structures and Algorithms
- Digital Electronics
- Introduction to Algorithms
- Mathematics for Computation Theory
- Numerical Analysis I
- Operating System Foundations
- Software Engineering and Design
- Comparative Programming Languages
- Compiler Construction

- These classes are like modules, ranging in length from a few weeks to spanning across terms. It is easy to find some classes that will fit into your schedule.
- Classes consist of 2 or 3 lectures a week, in addition to a few supervisions (# decided by you).
- Final exams are all at the end of the year – first week of June

## Useful Links

- Student Resources: <http://www.cl.cam.ac.uk/UoCCL/teaching/current.html>
- Class Schedule: <http://www.cl.cam.ac.uk/UoCCL/teaching/lectlist/landscape.pdf>
- Contact me with any questions: [prentice@mit.edu](mailto:prentice@mit.edu)

# Resources Before You Go

- Little brown book (Engineering Department)
- CUED CD – 2<sup>nd</sup> year material
- Map of Cambridge

# When You Get There

- Fresher's Handbook
- Data Books – good to know what is in them (what you can assume available on exams)

# Useful Links

- Year 3 Module Syllabi
  - <http://www.eng.cam.ac.uk/teaching/courses/y3/3b1.html>  
(and similarly for other modules)
- Tripos Papers and Cribs
  - <http://www.eng.cam.ac.uk/DesignOffice/tripos/index.html>  
(you will need CUED userid and pin)

# Books Worth Owning

- 3F2: Modern Control – Dorf
- 3B3: Power Electronics – Mohan
- 3B5: Solid State Electronics – Streetman
- 3I1: Algorithms
- 3F1 and reference for all 3Fx courses: Signals & Systems – Oppenheim & Willsky
- Swap system
  - CMI exchange setting this up to help with finding/leaving books, bikes, etc. in Cambridge

## Summer (Long Vacation) Preparation

- CUED assigns a summer reading list
  - Says that students should spend 80 hours over the summer reading material before arriving for the 3<sup>rd</sup> year modules
  - CU students rarely actually do this
  - Access to texts difficult over the summer