Curriculum, B.Sc. in Electrical and Electronics Engineering

Semester 1 (Taught in the Fall)

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.1820	Introduction to Computer Science using Python	3	2	-	2	4	-
0595.1824	Linear Algebra	6	5	2	-	7	-
0595.1826	Physics 1A	7	8	4	-	12	-
0595.1846	Calculus 1B	5	4	2	-	6	-
Total Semester		**21**	**19**	**8**	**2**	**29**	

* Course includes Methods in Mathematical Physics at a scope of 2 credit points

Semester 2 (Taught in the Spring)

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.1829	Physics 2A	6	5	3	-	8	Phys. 1A
0595.1847	Calculus 2B	5	4	2	-	6	Calc. 1B
0595.1845	Ordinary Differential Equations	3.5	3	1	-	4	Calc. 1B; Linear Algebra
0595.1821	Programming 2 – C	2	2	2	-	4	Intro to CS using Python
0595.3561	Digital Logic Systems	3.5	3	1	-	4	Linear Algebra
Total Semester		**20**	**17**	**9**	**0**	**26**	

* Course includes Methods in Mathematical Physics at a scope of 2 credit points

Cr. = Credits ; Lec. = Lectures ; Rec. = Recitations; Lab. = Laboratory

Semester 3 (Taught in the Fall)

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.2804	Numerical Analysis	3.5	3	1	-	4	ODE; Intro to CS using Python
0595.2830	Quantum and Solid state Physics	5	4	2	-	6	Phys. 2A
0595.2843	Harmonic Analysis	2.5	2	1	-	3	Calc. 2B; ODE; Complex Functions (in parallel)
0595.2844	Complex Functions	2.5	2	1	-	3	Linear Algebra ; Calc. 2B
0595.2832	Circuits and Linear Systems	5	4	2	-	6	ODE; Phys. 2A
0595.1000	MATLAB Solution of Engineering Problems	1.5	1	1	-	2	Circuits and Linear Systems (in parallel)
Total Semester		**20**	**16**	**8**	**0**	**24**	

Semester 4 (Taught in the Spring)

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.2510	Data Structures and Algorithms	3.5	3	1	-	4	Programming 2 – C; DLS
0595.2846	Partial Differential Equations	2.5	2	1	-	3	ODE; Complex Functions; Harmonic Analysis
0595.2508	Electronic Devices	5	4	2	-	6	Quantum and Solid state Physics
0595.2801	Introduction to Probability and Statistics	3.5	3	1	-	4	Calc. 2B
0595.2835	Signals and Systems	3.5	3	1	-	4	Harmonic Analysis; Circuits and Linear Systems
0595.2525	Electromagnetic Fields	3.5	3	1	-	4	Harmonic Analysis ; Phys. 2A; PDE (in parallel)
Total Semester		**21.5**	**18**	**7**	**0**	**25**	

Cr. = Credits ; Lec. = Lectures ; Rec. = Recitations; Lab. = Laboratory

Semester 5 (Taught in the Fall)

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.3513	Analog Electronic Circuits	5	4	2	-	6	Elect. Devices ; Circuits and Linear Systems
0595.3591	Electronics Laboratory (1)	2	-	-	4	4	Elec. Devices ; Prob. and Stat.; Signals and Systems; Analog Elec. Circuits (in parallel)
0595.3543	Introduction to Control Theory	2.5	2	1	-	3	Linear Circuits and Systems
0595.3632	Random Signals and Noise	4	3	2	-	5	Prob. And Stat. ; Signals and Systems
0595.3526	Wave Transmission	3.5	3	1	-	4	Electromagnetic Fields
0595.3571	Energy Conversion	3.5	3	1	-	4	Circuits and Linear Systems; Electromagnetic Fields
Total Semester		**20.5**	**15**	**7**	**4**	**26**	

Semester 6 (Taught in the Spring)*

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.3514	Digital Electronic Circuits	3.5	3	1	-	4	DLS; Analog Elect. Circuits
0595.3592	Electronics Laboratory (2)	2	-	-	4	4	Elect. Lab.1; Analog Elect. Circuits
0595.3572	Energy Conversion Laboratory	1	-	-	2	2	Energy Conversion; Elect. Lab.1
Total Semester		**6.5**	**3**	**1**	**6**	**10**	

* In addition, the program of this semester contains 8-10 hours of Specialization Courses and Labs from the list in the Table below

Cr. = Credits ; Lec. = Lectures ; Rec. = Recitations; Lab. = Laboratory

Semester 7(Taught in the Fall)*

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.4001	Project (phase a)	0	-	-	0	0	Satisfactory completion of third year.
0595.3593	Electronics – Laboratory (3)	2	-	-	4	4	Electronics Lab.2 ; Digital Electronic Circuits
Total Semester		**2**	**0**	**0**	**4**	**4**	

* In addition, the program of this semester contains 12-14 hours of Specialization Courses and Labs from the list in the Table below

Semester 8 (Taught in the Spring)*

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.4000	Project (phase b)*	6	-	-	4	4	Satisfactory completion of Phase a
Total Semester		**6**	**0**	**0**	**4**	**4**	

* Academically, this course is equivalent to a 12-hour course. The 4-hour allocation is for tuition purpose only.
* In addition, the program of this semester contains 16-22 hours of Specialization Courses and Labs from the list in the Table below

Total basic program		**117.5**	**88**	**40**	**20**	**148**	

Cr. = Credits ; Lec. = Lectures ; Rec. = Recitations; Lab. = Laboratory

Specialization Courses

The Specialization Courses are scheduled in Semesters 6- 8 depending on teacher availability and other considerations. Each course is accompanied by a Specialization Lab. Lab meetings are typically 4-hour long, and are scheduled for part of the semester. The number of hours shown in the Table reflects to overall meeting-hours during the semester, such that 1 hours represent 13 meeting hours.

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.4200	Introduction to Digital Signal Processing	3.5	3	1	-	4	Random Signals and Noise
0595.4100	Communication Systems	3.5	3	1	-	4	Random Signals and Noise
0595.4362	Practical Feedback Systems	3.5	3	1	-	4	Introduction to Control Theory
0595.4495	Introduction to Computer Structure & Operating Systems	3.5	3	1	-	4	Data Structure and Algorithms
0595.4703	Introduction to VLSI Design	3.5	3	1	-	4	DLS; Electronic Devices
0595.4508	Power Electronics	3.5	3	1	-	4	Energy Conv. ; Energy Conv. Lab
0595.4863	RF Circuits and Antennas	3.5	3	1	-	4	Wave transmission
0595.4293	Digital Signal Processing Lab	1	-	-	2	2	Digital Signal Processing
0595.4193	Communication Lab	1	-	-	2	2	Communication Systems
0595.3544	Control Lab	1	-	-	2	2	Introduction to Control Theory
0595.4494	Computer Structure Lab	2.5	-	-	5	5	-
0595.4793	VLSI Lab	0.5	-	-	1	1	DLS; Electronic Devices; VLSI course (in parallel)
0595.4592	Power Electronics Lab	0.5	-	-	1	1	Power Electronics
0595.4892	Microwave Lab	0.5	-	-	1	1	RF Circuits and Antennas
Total		**31.5**	**21**	**7**	**14**	**42**	
Total Program		**149**	**109**	**47**	**34**	**190**	

Entrepreneurship track – Optional courses

Students are entitled to take an Entrepreneurship Track offered by TAU International, in collaboration with the Recanati Business School.

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
1221.8000	Entrepreneurship from A to Z	3	3	-	-	3	-
1221.8005	Foundations of Entrepreneurship	3	3	-	-	3	-
1221.8000	Innovation – Theory and practice	3	3	-	-	3	-

Introduction to Computer Science using Python

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PREREQUESITES: No

WAY OF TEACHING: Lectures = 2 hours/week; Laboratory = 2 hours/week

COURSE DESCRIPTION

The course presents programming principles in Python. The course mainly deals with the applicative aspects of programming and students will acquire basic programming skills.

COURSE TOPICS

The course deals with general topics: Python programming language, use of external libraries, recursion, runtime analysis of sorting algorithms, dynamic programming, exception handling, IO and more. On the applicative side, the course will present applications from different fields of engineering and computer science: simulation, optimization, data analysis, signal processing, GUI and more.

HOMEWORK POLICY

There will be 10 homework assignments during the course and students will be required to submit and pass (grade >= 60) at least 9 homework assignments in order to complete the course.

Homework assignments and solutions will be displayed continuously on the course site in MOODLE. Homework is calculated as 25% of the final grade and will be given out every one or two weeks.

MIDTERM POLICY

A midterm exam will be scheduled in the beginning of the semester. During an examination, student shall not use books, papers, or other materials not authorized by the instructor. The midterm count for 15% of the final grade.

FINAL POLICY

The final exam will cover the entire course material and will count for 60% of the total course grade. The duration will be 3 hours. During an examination, student shall not use books, papers, or other materials not authorized by the instructor.

Students will have a first exam, Moed A. If the student does not pass, they can retake the exam, Moed B. The last exam taken will be the student's final grade for the exam.

REQUIRED READING

• Book: Think Python, by Allen B. Downey http://greenteapress.com/thinkpython/thinkpython.html

• The official language manual: Python 2.x documentation http://docs.python.org//

Linear Algebra

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PREREQUESITES: No

WAY OF TEACHING: Lectures = 5 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION

The goals are using and understanding main notions of linear algebra such as matrices, determinants, vector spaces, linear operators, inner products.

COURSE TOPICS

Week 1: Fields-Rational, real complex, examples of finite fields.

Week 2: Algebra of Matrices-Addition, multiplication by scalar, multiplication transposition, inversion.

Week 3-4: Linear equations-Row operations on matrices, row equivalence, the row echelon form, row rank, homogeneous and non-homogenous systems of equations, consistency conditions, general solution.

Week 5-6: Vector Spaces-subspaces, linear independence, bases and change of bases, dimention, row and column spaces of matrices, equivalence relations and canonical forms of matrices.

Week 7-8: Determinants-Permutations, definition of determinant and its properties, product formula, expansion by row (column), minors, adjoint matrix, Cramer's Formulas.

Week 9: Linear transformation: Matrix of representation and its behavior with respect to change of basis.

Week 10-11: Eigenvalues and eigenvectors ofoperators-characteristic polynomial, similarity, invariant subspace, algebraic and geometric multiplicities, criteria for triangularization and diagonalization.

Week 12-13: Spaces with inner products: Gram matrix and its behaviour with respet to change of basis, norms, orthogonal and orthonormal bases, Pythagoras' theorem, orthogonal and unitary matrices, projections, orthogonal complement, Gram-Schmidt orthogonalization, Bessel inequality, Cauchy-Schwarz inequality.

Week 14: Operators in spaces with inner product: linear functionals, Riesz' representation theorem, adjoint operator; unitary, orthogonal and self-adjoint operators, orthogonal triangularization and diagonalization.

REQUIRED READING

- H. Schneider and G.P. Barker: *Matrices and Linear Algebra*, Dover, 1989.

ADDITIONAL READING

- S. Lang, *Introduction to Linear Algebra*, 2nd edition, Springer, 1986.
- S. Lipschutz and M. Lipson, *Schaum's Outline of Linear Algebra*, 3rd edition, McGraw-Hill, 2000.

Physics 1A

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PREREQUESITES: No

WAY OF TEACHING: Lectures = 8 hours/week; Recitations = 4 hours/week

COURSE DESCRIPTION

This is an introductory, calculus-based course in mechanics, for undergraduate engineering students. The course covers the concepts of translational and rotational kinematics and dynamics, static and dynamic equilibrium of rigid bodies, oscillations and classical gravitation theory. These concepts are illustrated with a wide variety of examples and explanations of everyday phenomena. Moreover, the course covers various mathematical techniques in calculus that are needed for the study of classical physics.

COURSE POLICY

- Assignments will be given by the recitation instructor on a weekly basis. 80% of all homework assignments must be handed in for evaluation, as a mandatory requirement for passing the course.
- A midterm exam will be scheduled in the beginning of the semester. During the midterm, students may use one formula sheet and a simple calculator (without an internet connection). No other material is allowed!
- A Final Exam will take place at the end of the semester. There will be a choice of 3 out of 4 questions, and its duration: 3 hours. During the final exam, students may use one formula sheet and a simple calculator (without an internet connection). No other material is allowed!
- The midterm covers the first six weeks of the semester and serves as a protective grade: it will count for 19% of the total course grade only if its grade is higher than the that of the final exam.
- The final exam will cover the entire course material and will count for 81%-100% of the total course grade.

COURSE TOPICS

Week	Topics in Physics	Topics in Calculus
1	Galileo's Kinematics	The concept of Derivative. Techniques of differentiation
2	Newton's Laws	Indefinite Integrals.
3	Newton's Laws and Vector Properties	Definite Integrals
4	Circular Motion and Polar Coordinates	Rectangular, Spherical and Cylindrical Coodinates in 3D-Space.
5	Work and Mechanical Energy.	Line Integrals
6	Equilibrium conditions. Conservation of Momentum. Center of mass.	Partial Derivatives, Conservative Fields and Gradients
7	Systems with variable mass and time dependent motion.	First-order ODE: Separation of variables and Integrating Factors
8	Statics. The concept of Torque.	Taylor Series

9	Conservation of Angular Momentum	Second-order Homogeneous and Inhomogeneous linear constant coefficient ODE
10	Rigid body mechanics, moment of inertia, precession. The gyroscope.	Multiple Integrals
11	Harmonic motion: simple, forced and damped.	
12	Pseudo Forces. Centrifugal and Coriolis forces.	
13	Gravitation, Kepler's laws, motion of satellites.	

REQUIRED READING

- D. Halliday, R. Resnick, and K. S. Krane: *Physics*, 5th edition, vol. 1 (Wiley)
- Alonso and Finn: *Fundamental University Physics*, vol 1 – Mechanics (Addison Wesley)
- H. Anton: *Calculus, A New Horizon*, 6th edition (Wiley)

Calculus 1B

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PREREQUESITES: No

WAY OF TEACHING: Lectures **=** 4 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION

We are going to investigate real-valued functions of a single variable. That includes, in particular, limits, differentiation and integration of the functions, investigation of their extremum, approximation of the functions by polynomials. But, first, we start with numerical sequences and series and conclude the course with sequences and series of functions of a single variable.

COURSE TOPICS

Week 1-2-3: Topics from the set theory. Infinite sequences. Limit of sequences, divergence, monotonic sequences, the sandwich theorem, subsequences, Bolzano-Weierstrass theorem. Cauchy characterization of convergence. Infinite series, convergence and divergence of series, convergence tests of series. Absolute and conditional convergence.

Week 4-5: Real-valued functions, increasing and decreasing functions, inverse functions, composition of functions. Elementary functions: linear and quadratic, polynomials, power, exponential, logarithmic, trigonometric and their inverse, hyperbolic, absolute value, floor function. Informal definition of limit of functions and continuity **-** using sequences and epsilon-delta, one-sided limits and continuity. The intermediate value theorem, Weierstrass theorem.

Week 6-7: Uniform continuity. Number e as a limit, the limit of Sin(x) divided by x. Derivative as a tangent slope and a velocity, tangent and normal lines to functions. Calculating derivatives of polynomials, negative powers, Sin(x), Cos(x). Differentiation rules, derivative of tan(x) and inverse functions. The chain rule, derivative of rational powers, derivatives of sinh(x), cosh(x), tanh(x). Derivative of a in power x using the chain rule. The mean value theorems of Rolle and Langrange.

Week 8-9: Taylor's formula with a remainder and Taylor series, the proof of Taylor's formula with Lagrange remainder. Taylor's formula of elementary functions. Its application to l'Hopital's rule and to sufficient condition of an extremum. Convexity. Asymptotes. Investigation of a function.

Week 10-11: Indefinite integral, integral formulas: substitutions, integral of rational functions, integration by parts. Definite integral and area. The fundamental theorem of calculus. Integrals which depend on a parameter and their derivative with respect to the parameter. Applications of integrals: area between curves, the length of curves, volumes of solids of revolution, moments and centers of mass.

Week 12-13: Improper integrals. Evaluating integrals using series. Convergence of sequences and series of functions, uniform convergence, Weierstrass theorem. Changing the order between limit (sum) and integral, limit (sum) and derivative.

REQUIRED READING

- Protter and Morrey, *A first Course in Real Analysis*, 2nd edition, Springer, 1991.

ADDITIONAL READING

- Thomas and Finney: *Calculus and Analytic Geometry*, 9th edition, Addison-Wesley, 1996.
- Arfken and Weber, *Mathematical Methods for Physicists*, 4th edition, Academic Press, 1995.
- Any other book in calculus (for engineering faculties and higher) can be used.

Physics 2A

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PREREQUESITES: Physics 1A

WAY OF TEACHING: Lectures = 5 hours/week; Recitations = 3 hours/week

COURSE DESCRIPTION

This is an introductory, calculus-based course in classical electromagnetism, for undergraduate engineering students. The course covers the concepts of electrostatics, magnetostatics and electrodynamics, and formulates Maxwell's theory and equations. These concepts are illustrated with a wide variety of examples and explanations of everyday phenomena. Moreover, the course covers various mathematical techniques in Calculus, that are needed for the study of classical physics.

COURSE POLICY

- Assignments will be given by the recitation instructor on a weekly basis. 80% of all homework assignments must be handed in for evaluation, as a mandatory requirement for passing the course.
- A Final Exam will take place at the end of the semester. There will be a choice of 3 out of 4 questions, and its duration: 3 hours. During the final exam, students may use two formula sheets and a simple calculator (without an internet connection). No other material is allowed!
- The final exam will cover the entire course material and will count for 100% of the total course grade.

BOOKS

- D. Halliday, R. Resnick, and K. S. Krane: *Physics*, 5th edition, vol. 2 (Wiley)
- D.J. Griffiths: *Introduction to Electrodynamics* (also available online)
- H. Anton: *Calculus, A New Horizon*, 6th edition (Wiley)

All books are available at the Exact Sciences Library.

COURSE TOPICS

Week	Topics in Physics	Topics in Calculus
1	Electrostatics: Coulomb's Law, the Electric Field	Directional Derivatives and Gradients
2	Gauss' Law	Surface Integrals and Flux
3	Electrostatic potential and potential energy	The Divergence Theorem
4	Differential form of Gauss' Law,	Conservative 2-D Fields and Green's

	Poisson and Laplace equations	Theorem
5	Electrical properties of materials; capacitors and dielectrics	Conservative 3-D Fields and Stokes' Theorem
6	Electric currents and DC circuits	
7	The magnetic field: currents and charges in magnetic fields	
8	The Biot-Savart Law and Ampere’s Circuital Law	
9	Faraday’s Law of Induction	
10	Inductance	
11	Displacement current, Maxwell’s equations	
12	Magnetic properties of matter	
13	Electromagnetic waves	

Calculus 2B

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PREREQUESITES: Calculus 1B

WAY OF TEACHING: Lectures **=** 4 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION

This course is a continuation of the course "Calculus 1". We are going to study real-valued functions of several variables. That includes, in particular, limits, partial derivatives, directional derivative, investigation of the functions extremum, double and triple integrals of functions, line and surface integrals of scalar and vector functions, Green-Gauss-Stokes theorems.

COURSE TOPICS

Week 1-2: Topics from the analytic geometry. Limit and continuity of functions of two variables, partial derivatives, gradient, tangent and normal planes to a surface. Higher order partial derivatives. Differentiability. Directional derivative.

Week 3-4: The chain rule, implicit differentiation. Local extremum and global minimum/maximum. Lagrange multiplier method. Taylor's formula with Lagrange remainder. Vector functions and curves in the space.

Week 5-6: Double integrals, iterated integrals. Jacobian. Polar coordinates. Triple integrals over a parallelepiped.

Week 7-8-9: Triple integrals, iterated integrals. Jacobian. Cylindrical and spherical coordinates. Line integral of scalar functions. Line integral of vector functions. Work. Path independent line integrals (conservative fields). Green's theorem (in the plane).

Week 10-13: Surface area, parametric surfaces and surface integrals of scalar and vector functions. Vector fields: curl (rotor) and divergence. Theorems of Stokes and Gauss. Review session.

ASSIGNMENTS

75% of all homework assignments must be handed in for evaluation.

MIDTERM COURSE POLICY

A midterm exam will be scheduled in the beginning of the semester. During an examination, student shall not use books, papers, or other materials not authorized by the instructor. The midterm will count for 10% of the total course grade, and will be a multiple choice test (10 questions for 1.5 hours).

FINAL COURSE POLICY

The final exam will cover the entire course material and will count for 90% of the total course grade. There will be a choice of 4 out of 5 questions, where question 2 is obligated. The duration will be 3 hours. During an examination, students are permitted to bring 4 pages of formulas without including examples and their solutions, written by the student, and a basic calculator. Students will have a first exam, Moed A. If the student does not pass, they can retake the exam, Moed B. The last exam taken will be the student's final grade for the exam.

REQUIRED READING

- Protter and Morrey, *A first Course in Real Analysis*, 2^{nd} edition, Springer, 1991.

ADDITIONAL READING

- Thomas and Finney: *Calculus and Analytic Geometry*, 9^{th} edition, Addison-Wesley, 1996.
- Arfken and Weber, *Mathematical Methods for Physicists*, 4^{th} edition, Academic Press, 1995.
- Any other book in calculus (for engineering faculties and higher) can be used.

Ordinary Differential Equations

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PREREQUESITES: Calculus 1B; Linear Algebra

WAY OF TEACHING: Lectures **=** 3 hours/week; Recitations = 1 hour/week

COURSE TOPICS

Week 1: Examples from mechanics and electricity of problems involving initial or boundary conditions.
Week 2: First order equations, the existence and uniqueness theorem.
Week 3-4: Second order linear equations; homogeneous equations and linear independence, the wronskian and lowering the order of an equation, homogeneous equations with constant coefficients.
Week 5-6: Separation to a homogeneous and an inhomogeneous problem, the method of undetermined coefficients and the method of variation of parameters. .
Week 7: Generalization to nth order equations, the case of constant coefficients.
Week 8-9: The Laplace Transform and it's applications for solving differential equations, initial and final value theorems, transforms of convolutions.
Week 9-10: System of first order linear equations.
Week 11-12: Sturm-Liouville and self-adjoint problems, eigenfunctions and eigenvalues, oscillation of inhomogeneous equations by expansion in eigenfunctions in L2(R), uniform convergence of the expansion, the example of Fourier series.

ASSIGNMENTS

Students must submit at least 70% of the given homework assignments.

MIDTERM COURSE POLICY

A midterm exam will be scheduled in the beginning of the semester. During an examination, student shall not use books, papers, or other materials not authorized by the instructor. The midterm count for 15% of the final grade MAGEN.

FINAL COURSE POLICY

The final exam will cover the entire course material and will count for 85% of the total course grade. The duration will be 3 hours. During an examination, student shall not use books, papers, or other materials not authorized by the instructor.
Students will have a first exam, Moed A. If the student does not pass, they can retake the exam, Moed B. The last exam taken will be the student's final grade for the exam.

REQUIRED READING

Boyce W. and R.D. Prima: *Elementary differential equations and boundary value problems,* Wiley, last edition

ADDITIONAL READING

There is no additional reading for this course

Programming 2-C

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PREREQUESITES: Introduction to Computer Science using Python

WAY OF TEACHING: Lectures **=** 2 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION

This is a second programming course that concentrates on functional and low level programming as well as modularity. The course will include large scale programming assignments.

COURSE POLICY

1. During an examination, student shall not use books, papers, or other materials not authorized by the instructor.

2. The final exam will cover the entire course material, and its duration: 3 hours.

3. 40-45% of the final grade will be based on student assignments.

4. Student are expected to solve the home assignments individually.

COURSE TOPICS

Introduction to computer structure and operating systems.

Programming in “C”: variables, expressions, program flow control, functions, pointers, structures. Input/Output, sorting algorithms, modular program design.

EVALUATION

The course grade will be calculated based on the following scheme:

	Weighting
Individual home assignments	15%
Project	30%
Final Exam	55%

REQUIRED READING

Brian W. Kernighan and Dennis M. Ritchie. The C Programming Language. 2nd ed., March 1988. Prentice Hall. ISBN 0-13-110362-8.

Multiple copies of the book are available at the Exact Sciences and Engineering Library.

Digital Logic Systems

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PREREQUESITES: Linear Algebra

WAY OF TEACHING: Lectures **=** 3 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION

In this course we teach digital design. We first discuss Boolean algebra and the implementation of Boolean equations using gates. Then we use gates to build the basic building blocks of Multiplexors and Decoders. At this stage, we will discuss Fixed Point Arithmetic. Then, we will continue building devices such as Adders, Arithmetic Logic Unit, Registers, Counters, State-Machines etc. We will measure the cost and delay of each of the circuits we build. We will also show the principles of VHDL and how we describe all of these components in VHDL.

As an example for a complex system design we then design a simplified MIPS CPU. We introduce the instruction set the MIPS, a simple RISC CPU. Following is an implementation of a basic single cycle MIPS in which the data path and the control part are designed in detail. The next stage is a multi-cycle implementation of the same CPU.

The course gives a solid ground of digital design and the understanding of a basic CPU.

COURSE TOPICS

Lecture 1-2: Boolean algebra and basic building blocks

* Boolean algebra theorems
* Logical variables and functions
* AND, OR, NOT
* De-Morgan's theorem
* XOR, NAND, NOR
* Sum of products and product of sums
* Simplification of logical functions using Boolean algebra theorems
* Circuit implementation using gates.
* Universal systems
* The delay of a gate
* Building multiple inputs gates efficiently (using 2 input gates), and similarly, Decoders and Multiplexers.

Lecture3: Karnaugh Maps

* The principle of simplifying sum of products equations
* Karnaugh maps as a truth table with hamming distance of 1
* Simplification of 3 variables equations using Karnaugh maps
* Simplification of 4 variables equations using Karnaugh maps
* Don't care utility for function minimization

Lecture4: Fixed point arithmetic

* Bases (decimal, binary, Hexadecimal) and conversions
* Representation of unsigned numbers
* Representation of fractions
* Unsigned addition and subtraction
* Two’s complement numbers
* Negating a 2’s comp. number
* Comparison of unsigned and 2’s comp. numbers

Lecture5: ALU

* Half adder
* Full adder
* Ripple Carry Adder
* Building an ALU

Lecture6: Fast adders

* Conditional sum adder
* Carry Look-ahead adder

Lecture7: Sequential logic

* SR latch
* D latch
* T latch
* JK latch
* Mater-Slave D FF
* Timing issues
* A FF with a write enable
* A shift register

Lecture 8: Sequential logic continued

* A register with a write enable
* Synchronous counters
* Moore Finite State Machine
* A sequence detector

Lectures 9: Introduction to VHDL

* Combinational processes
* Sequential processes
* Entities and component
* Examples
* VHDL demo

Lectures 10: MIPS instruction set and Assembly language

* MIPS R2000 Assembly language
* Representation of instructions
* Addressing modes
* Compiler, Linker, Loader

Lectures 11: Single cycle architecture

* Data path for R-type instruction
* Data path with I-type instructions
* Data path with J-type instruction
* Control of single cycle architecture
* Drawbacks

Lectures 12: Multi-Cycle architecture

* The principle of Multi-Cycle architecture
* Implementation of the Data Path in multi-cycle architecture
* The control

* The state diagram

Lectures 13: MIPS vs. DLX

* The differences between MIPS and DLX
* If time permits: Preparation for the exam – Solving past exams

REQUIRED READING

- Lecture notes that can be downloaded from the course web page

- "Computer Organization & Design: The Hardware/Software Interface", by D. A. Patterson and J. L. Hennessy, Morgan Kaufman Publishers, Inc. 2^{nd} edition, 1998, or 3^{rd} edition, 2005, or 4^{th} edition, 2009.

GRADING – Method: Participating in classes and submitting homework every week

The students' obligations:

- Need to attend lectures and recitations
- Homework should be submitted when specified
- At least 80% of the homework should be submitted – This is a pre-requisite for attending the exam
- Late submission requires the instructor approval
- The final grade is made of 15% the homework grade, 15% of the midterm exam and 70% the exam grade (if the exam grade is higher that the midterm exam grade, then final grade will be made of 15% the homework grade, 5% of the midterm exam and 80% the exam grade)

Numerical Analysis

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PREREQUESITES: ODE; Introduction to Computer Science using Python

WAY OF TEACHING: Lectures **=** 3 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION

This course intends to introduce the student to the practical world of solving common mathematical problems numerically in a fast and reliable way. It emphasizes approximations and the control of errors in the numerical solution. It is of utmost importance in the information age to giants like Google, in many companies that use signal and image processing and in various start-ups. The information revolution brings a constant and growing need for good numerical solvers for complex and complicated problems. The problems that are treated in this course are from calculus and from Linear algebra. The course includes an introduction to the solution of differential equations as well.

COURSE TOPICS

Week 1-2: Floating point analysis, Polynomial Interpolation

Week 3-4: Solution of non-linear equation and fixed point schemes

Week 5-6-7: Numerical linear algebra,

Week 8-9-10: Numerical differentiation & Integration

Week 11-12: Least square methods

Week 13-14: Orthogonal polynomials & Introduction to numerical solutions of ordinary differential equations with boundary conditions.

REQUIRED READING

- S. D. Conte and C. de Boor, Elementary Numerical Analysis 1972

Quantum & Solid State Physics

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PREREQUESITES: Physics 2A

WAY OF TEACHING: Lectures **=** 4 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION

Quantum Mechanics of atoms and solid State

COURSE TOPICS

Week 1: Introduction to Quantum mechanics: The photoelectric effect, two-slit diffraction, de-Broglie Rutherford & Bohr's models of the atoms, black body radiation, development of the Schrodinger equation from basic principles.

Week 2: Mathematical background-vector spaces, operators, Hermitian and Unitary operators, the eigenvalue problem.

Week 3: The postulates of quantum mechanics, the physical interpretation of the wave function, use of operators, measurement process, uncertainty principle.

Week 4: The Time Independent Schrodinger Equation-Free particle, particle in an infinite and finite potential well, tunneling.

Week 5: Particle in a harmonic potential.

Week 6: angular momentum and the Hydrogen atom.

Week 7: The time dependent Schrodinger equation, the relation to the time independent equation, spanning the solution in the energy basis.

Week 8: Atomic orbitals and chemical bonds.

Week 9: Crystal structure

Week 10: Kroning-Pennei model, Bloch Theorem, reciprocal lattice (in one dimension), energy band structure in a crystal

Week 11: Effective mass, density of states

Week 12: Identical particles-Boltzmann, Fermi-Dirac and Bose-Einstein distributions

Week 13: Carrier concentration, intrinsic Fermi level.

Week 14: Extrinsic semiconductors

REQUIRED READING

- Tang: *Fundamentals of quantum mechanics*, Cambridge press.

ADDITIONAL READING

- Kittel, *Introduction to solid state physics,* John Wiley & Sons.
- Miller, *Quantum mechanics for scientists and engineers.*
- Schiff, L. *Quantum mechanics.*
- Pierret. *Advanced semiconductor Fundamentals,* Prentice Hall.
- Ashcroft, *Solid State Physics*, Harcourt college publishers.

Harmonic Analysis

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PREREQUESITES: Calculus 2B; ODE; Complex Functions (in parallel)

WAY OF TEACHING: Lectures **=** 2 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION

The aim of this course is to introduce the fundamentals of Harmonic analysis. In particular, we focus on three main subjects: the theory of Fourier series, approximation in Hilbert spaces by a general orthogonal system and the basics of the theory of Fourier transform.

Harmonic analysis is the study of objects (functions, measures, etc.), defined on different mathematical spaces. Specifically, we study the question of finding the "elementary components" of functions, and how to analyze a given function based on its elementary components. The trigonometric system of cosine and sine functions plays a major role in our presentation of the theory.

The course is intended for undergraduate students of engineering, mathematics and physics, although we deal almost exclusively with aspects of Fourier analysis that are useful in physics and engineering rather than those of pure mathematics. We presume knowledge in: linear algebra, calculus, elementary theory of ordinary differential equations, and some acquaintance with the system of complex numbers.

COURSE TOPICS

Week 1: Fourier series of piecewise continuous functions on a symmetrical segment. Complex and real representations of the Fourier series.

Week 2: Bessel Inequality, the Riemann-Lebesgue Lemma, partial sums.

Week 3: Convergence theory, the Dirichlet kernel, the Dirichlet Theorem

Week 4: Fourier series on general segments, differentiability and integrability

Week 5: Smoothness and coefficients decay, the Gibbs phenomenon, the Riemann localization principle

Week 6: Inner product spaces, orthonormal bases

Week 7: Cauchy sequences and complete spaces, complete systems, the completeness of the trigonometric system

Week 8: Generalized complete systems, convergence in norm, back to Bessel and the Parseval's equation

Week 9: Hilbert spaces, Banach spaces, best approximation in Hilbert spaces, generalized Phythagoras Theorem

Week 10: Fourier Transform for functions L1, basis properties and convolution

Week 11: The inverse Fourier transform, Plancherel's Theorem

Week 12: The definition of the Fourier transfer in L2, smoothness theorems and the Riemann-Lebesgue for the Fourier transform

Week 13: (As time permits) An introduction to Nyquist-Shannon sampling theorem and ideal low pass filter.

REQUIRED READING

- Folland, G.B.: *Fourier Analysis and its applications*, Wadsworth & Brooks/Cole mathematics series 1992 (available in the library of Exact Sciences & Engineering, location 515:3 FOL).

ADDITIONAL READING

- Katznelson, Yitzhak. *An introduction to Harmonic analysis*. Cambridge University Press, 2004. Available online, for example in google books.

Complex Functions

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PREREQUESITES: Calculus 2B, Linear Algebra

WAY OF TEACHING: Lectures = 2 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION

This course is an introduction to the theory of analytic functions of one complex variable. Main topics include Cauchy's theorem, series representation of analytic functions, i.e. Taylor and Laurent series, residue theorem, evaluation of improper real integrals using the residue theorem.

COURSE TOPICS

Week 1: The Field of complex numbers: The algebra and geometry of complex numbers. Polar representation. Complex conjugate. Absolute value. Euler identity and De-Moivre's formula: Powers, roots and geometric interpretation.
Week 2: Series of Complex numbers and convergence. Topology: Regions on the complex plane, e.g. disk, annulus, limits in the complex plane

Week 3-4: Functions of a complex variable. Image, limits, continuity and derivatives of complex functions, differentiation rules, Cauchy-Riemann equations and consequences.

Week 5-6: Elementary functions, i.e. exponential function, logarithmic function, trigonometric functions, hyperbolic functions, inverse functions. The logarithmic and exponential functions. Powers, roots and their geometrical interpretations. Branches of multi-valued functions and analytic branches.

Week 7-8: Path integration in the complex plane. Evaluation Theorem. Connected and simply connected regions. Cauchy's theorem. Morera's Theorem.

Week 9: Cauchy's integral and its use to evaluate derivatives. Any order derivatives of analytic function. Liouville's theorem for entire functions. The fundamental theorem of algebra. Maximum and minimum principals.

Week 10-11: Power series. Radius of convergence. Cauchy-Hadamard's formula for radius of convergence. (Local) Uniform convergence. Weierstrass M-test for uniform convergence of power series. Term by term differentiation \ integration. Uniqueness Theorems.

Week 12: Laurent and Taylor series and isolated singular points of analytic functions. Casorati Weierstrass Theorem.

Week 13: Residue Theorem and its applications. Calculation of improper integrals of real valued functions using the residue theorem (If time permits) The argument principle. Rouche's theorem.

RECOMENDED READING

- James Ward Brown & Ruel V. Churchill, "Complex Variables and Applications", McGraw-Hill, Inc. 1996.
  D. Zill, P. Shanahan, "Complex Variables with Applications", Jones and Bartlett Publishers.

ADDITIONAL READING

- Saff, Edward B., and Arthur David Snider. *Fundamentals of Complex Analysis with Applications to Engineering, Science, and Mathematics.* 3rd ed. Upper Saddle River, NJ: Prentice Hall, 2002. ISBN: 0139078746.

- Sarason, Donald. *Complex Function Theory.* American Mathematical Society. ISBN: 0821886223

- Alfhors, Lars. Complex Analysis: *An Introduction to the Theory of Analytic Functions of One Complex Variable.* McGraw-Hill Education, 1979. ISBN: 0070006571.

- Saff, Edward B., and Arthur David Snider. *Fundamentals of Complex Analysis with Applications to Engineering, Science, and Mathematics.* 3rd ed. Upper Saddle River, NJ: Prentice Hall, 2002. ISBN: 0139078746.

Circuits and Linear Systems

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PREREQUESITES: ODE; Physics 2B

WAY OF TEACHING: Lectures **=** 4 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION

The course "Circuits & Linear Systems" introduces the fundamental engineering tools that will accompany the students along their way in the faculty. The tools include functions, operators, rigorous display forms for problem solutions and common electric components.

The course team offers a variety of aids that enable the students to deepen and broaden their knowledge of the course subjects. The course website offers the recitations, homework assignments and their solutions. The course team will provide the students with office hours that may be utilized.

Please follow all the administrative information that will be given during the semester through the course website at MOODLE.

COURSE TOPICS

Week 1-2: Static electrical circuits: Kirchhoff's Circuit Laws, electrical circuit components, superposition, Thévenin and Norton equivalents.

Week 3-4: Dynamic electrical circuits: dynamic elements, first and second order circuits and the associated differential equations (without solution), sinusoidal steady state and phasors, real and reactive power.

Week 5: Coupled elements, controlled voltage sources and current sources, nonlinear elements, linearization; system classes: linear, continuous, distributed, causal, time invariant.

Week 6: Linear, Time-Invariant (LTI) systems: wave functions (step, ramp, delta functions), ordinary differential equations, time-domain solution (ZIR+ZSR).

Week 7: Impulse response and convolution. First and second order systems – time constants, decay and damping factor, resonance.

Week 8: Laplace transforms, first and second-order system solution, the Transfer Function.

Week 9: Stability and feedback, mathematical models for linear systems: electrical circuits as models for mechanical systems – translational and rotational systems.

Week 10-11: State-space representation of LTI systems, equivalent presentations, solutions in time domain and using Laplace transform

Week 12-13: Frequency-domain representation of LTI systems: steady-state response to sinusoidal inputs, transfer functions, phasors, zeros and poles, the frequency response as the Fourier transform of the impulse response, Bode plots, system stability.

ASSIGNMENTS

85% of all homework assignments must be handed in for evaluation.

While the correctness of your answers is not marked (you can compare your solutions with those we post online) – we will check the effort put in and the quality of your solutions. **This means incomplete (just final results), partial (missing sections) or delayed unapproved submissions will affect your assignment grade.** The assignments grade will count for 10% of the total course grade.

MIDTERM COURSE POLICY

A midterm exam will be scheduled in the beginning of the semester. The midterm will count for 15% of the total course grade.

FINAL COURSE POLICY

The final exam will cover the entire course material and will count for 75% of the total course grade. Students will have a first exam, also known as "Moed A". According to the student decision, the student can retake the exam, "Moed B". The last exam taken will be the student's final grade for the exam.

REQUIRED READING

- C. A. Desoer and E. S. Kuh, "*Basic Circuit Theory*" McGraw-Hill International Edition.
- Introduction for Electrical Engineering – lectures summary (available on Moodle).
- Introduction for Linear Systems – lectures summary (available on Moodle).
- D'Azzo and Houpis, "*Linear Control System Analysis and Design*" McGraw Hill, International Edition

MATLAB Solution of Engineering Problems

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PREREQUESITES: Circuits and Linear Systems (in parallel)

WAY OF TEACHING: Lectures = 2 hours/week

COURSE DESCRIPTION

This course starts by providing an introduction to programming using MATLAB; it then moves on to solving practical engineering problems using MATLAB. The course consists of interactive lectures and tutorials, with students solving sample problems using MATLAB in real time within the tutorials. Problem-based MATLAB homework assignments are given weekly. To pass, a student must successfully complete all assignments.

We are going to look at various engineering problems from different fields – for example differential equations, linear algebra, physics, harmonic analysis – and use MATLAB to investigate the problem, solve it, and finally validate our solution.

COURSE TOPICS

Week	Subject	Details	Main MATLAB Functions Introduced
1	Intro to MATLAB	Variables, vectors, matrices, operations (transpose, conjugate transpose, multiplication, inner multiplication, etc.), A(:) notation, random number generators, operations on vectors (length, etc.), searching for MATLAB built-in functions	rand, randn, length, find, unique, mean, var
2	Intro to MATLAB	for, while, plots, structures, scripts and functions, profiler	For, while, plot, semilog
3	Linear Algebra	Determinant, rank, vector product, scalar product, inner product, rotation matrices, matrix inversion, matrix inversion lemma	Inv, det, rank
4	Linear Algebra	Writing and solving sets of linear equations, Gauss elimination, Cramer's rule, eigenvalues and Eigenvectors	eig,
5	Differentials and Integrals	Numerical integration, limits of sequences, Taylor’s series,	
6	Physics	Harmonic motion, Newton’s laws (including friction)	
7	Ordinary Differential Equations	Numerical approximations, example using Kirchhoff's law, matrix exponential	Exp,
8	Harmonic Analysis	Fourier series, Gibbs phenomenon	linspace
9	Harmonic Analysis	Fourier transform including properties (linearity, time shift, frequency shift, scaling), convolution	fft, ifft, fftshift, conv
10	Linear Systems	Impulse response, response to sinewave, magnitude and phase of transfer function,	Freqz
11	Linear Systems	convolution, response to several sinewaves	Conv
12	Numerical Analysis	Newton Raphson, approximations of solutions of ordinary differential equations (Runge Kutta)	

ASSIGNMENTS

100% of all homework assignments must be handed in for evaluation. Assignments will be carried out and handed in by groups of 2 students.

GRADING

The course grade will be based on all homework assignments. There will be no final exam.

SUGGESTED READING

- Duffy, *Advanced Engineering Mathematics with MATLAB*, 2^{nd} edition, CRC, Chapman & Hall, 2003.
- Butt, *Introduction to Numerical Analysis using MATLAB*, Jones and Bartless Publishers, 2009.

Data Structures and Algorithms

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PREREQUESITES: Programming 2 – C; DLS

WAY OF TEACHING: Lectures **=** 3 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION

This course aims to introduce you some basic data structures and algorithms which are to be used as tools in designing solutions to problems. You will become familiar with the specification, usage, implementation and analysis of these data structures and algorithms.

COURSE TOPICS

Weeks 1-2: Introduction: Searching an element in a sorted list, binary search. Rates of growth definitions: O(n), Ω(n), Θ(n). Algorithm Correctness and Run-time, complexity analysis.

Week 3-4: Sorting: Insertion Sort. Merge sort. Quick sort. Lower-bound on sorting by comparison and the notion of decision tree. Linear time sorting algorithms.

Week 5-8: Abstract Data types and data structures: list, stack and queue, priority queue and implementation with heaps. Binary search trees and 2-3 trees. Union-find.

Week 9-11: Algorithms Design Techniques: Divide and conquer. Greedy algorithms. Dynamic programming.

Week 12-14: Graph Algorithms: Definitions. Representations. Traversals, Finding minimum spanning tree. Maximum flow.

REQUIRED READING

- *Introduction to Algorithms*. Corman, Leiserson and Rivest (CLR)

ADDITIONAL READING

- *Data Structures and Algorithms*. Aho, Hopcroft and Ullman (AHU)

Partial Differential Equations

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PREREQUESITES: ODE; Complex Functions; Harmonic Analysis

WAY OF TEACHING: Lectures **=** 2 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION

We are going to study classical partial differential equation of elliptic, parabolic and hyperbolic types. Boundary and initial value problems are treated, in particular, Dirichlet, Neumann and Cauchy problems. The course, in particular, covers classical separation variable method, maximum principle, well-posedness questions.

COURSE TOPICS

Week 1: String or wave equation. Initial and boundary value conditions (fixed and free boundary conditions). The d'Alembert method for an infinitely long string.

Week 2: Wave problems for half-infinite and finite strings. Sturm-Liouville problem.

Weeks 3-4: A solution of a problem for a finite string with fixed and free boundary conditions by the method of separation of variables. The uniqueness proof by the energy method. Well-posedness of a vibrating string problem.

Week 5-6: Second order linear equations with two variables: classification of the equations in the case of constant and variable coefficients, characteristics, canonical forms. Laplace and Poisson equations. Maximum principle. Well-posedness of the Dirichlet problem.

Week 7-8: Laplace equation in a rectangle. Laplace equation in a circle and Poisson formula. A non-wellposed problem - the Cauchy problem. Green formula and its using for Neumann problems. Uniqueness of a solution of the Dirichlet problem.

Week 9-10: The method of separation of variables for the one-dimensional heat equation. Maximum principle. Uniqueness for the one-dimensional heat equation. The Cauchy problem for heat equations. Green function.

Week 11-13: Non-homogeneous heat equations, Poisson equations in a circle and non-homogeneous wave equations. Review session.

ASSIGNMENTS

75% of all homework assignments must be handed in for evaluation.

MIDTERM COURSE POLICY

A midterm exam will be scheduled in the beginning of the semester. During an examination, student shall not use books, papers, or other materials not authorized by the instructor. The midterm (for 1.5 hours) will count for 10% of the total course grade.

FINAL COURSE POLICY

The final exam will cover the entire course material and will count for 90% of the total course grade. There will be a choice of 4 out of 5 questions. The duration will be 3 hours. Students will have a first exam, Moed A. If the student does not pass, they can retake the exam, Moed B. The last exam taken will be the student's final grade for the exam.

REQUIRED READING

Tikhonov, A.N. and Samarskii, N.A: *Equations of Mathematical Physics,* Pergamon Press, Oxfort, 1963.
Weinberger, H.F, *A first Course in Partial Differential Equations*, Dover, NY, 1995.

Electronic Devices

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PREREQUESITES: Quantum and Solid State Physics

WAY OF TEACHING: Lectures **=** 4 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION & OBJECTIVES

At the end of this course students should be able to (i) model problems in a probability-theory setting; (ii) solve probability problems; (iii) know the main distributions and probability concepts used in following statistics courses.

COURSE TOPICS

Week 1: **Basics of probability:** Probability space, sets, events
Combinatorics: n! , n over k, probabilities over a symmetric sample space

Week 2: **Conditional probability:** Bayes' theorem, Dependent and independent events

Week 3: **Random variables:** Definitions of discrete and continuous random variables

Week 4: **Random variables (cont.):** Expectation, variance

Week 5: **Random variables (cont.):** Parametric random variables – binomial, geometric, hyper-geometric, poisson (and poisson process), exponential, normal

Week 6: **Joint Distributions**: Joint distribution, independent random variables

Week 7: **Joint Distribution (cont.):** Conditional distribution, conditional expectation and variance, covariance, Pearson correlation

Week 8: **Functions of several random variables**: Functions of several random variables, sum of random variables, expectation of sum of random variables

Week 9: **Covariance:** Variance of sum of random variables

Week 10: **Central Limit Theorem:** Normal distribution (cont.), t-distribution

Week 11: **Estimation:** Point estimation and interval estimation, quality of estimator (MSE)

Week 12: **Hypotheses testing**: H_0, H_1, type I and type II erros, power of test

Week 13: **Hypotheses testing (cont.):** z-test, one-sample t-test, paired t-test, independednt samples t-test

ASSIGNMENTS

Homework assignments will be distributed in class on a weekly basis with a due date of one week from the time of distribution. At the due date of each assignment, the corresponding solution will be distributed. Assignments will not be evaluated BUT submission will be recorded. 80% of all homework assignments must be handed in for evaluation in order to be eligible to take the final exam. Assignments are submitted during class.

MIDTERM COURSE POLICY

A midterm exam will be scheduled in the beginning of the semester. During an examination, student shall not use books, papers, or other materials not authorized by the instructor. The midterm will count for 20% of the total course grade.

FINAL COURSE POLICY

The final exam will cover the entire course material and will count for 80% of the total course grade. The duration will be 3 hours. Students will have a first exam, Moed A. If the student does not pass, they can retake the exam, Moed B. The last exam taken will be the student's final grade for the exam.

REQUIRED READING

Sheldon M. Ross: *A First Course in Probability* Pearson Prenticce Hall, 8th Edition, 2010.
Bertsekas, Dimitri P. and Tsitsikis, John N., *Introduction to Probability.* Athena Science, 2nd editions, 2008.
Montgomery, D.C and Runger, G.C. and Hubele, N.F. *Engineering Statistics*. Wiley & Sons, NY, 4th Edition, 2007.

Introduction to Probability and Statistics

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PREREQUESITES: Calculus 2B

WAY OF TEACHING: Lectures **=** 3 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION & OBJECTIVES

At the end of this course students should be able to (i) model problems in a probability-theory setting; (ii) solve probability problems; (iii) know the main distributions and probability concepts used in following statistic course.

COURSE TOPICS

Week 1: Basics of probability**:** Probability Space, Sets, Events Combinatory: n! , n over k, Probabilities over a symmetric sample space

Week 2: Conditional probability**:** Bayes' theorem, Dependent and independent events

Week 3: Random variables**:** Definitions of Discrete and continuous random variables

Week 4: Random variables (cont.): Expectation, Variance

Week 5: Random variables (cont.): special random variables – binom, geometric, hyper-geometric, Poisson (and Poisson process), exponential, Normal

Week 6: Joint Distributions: Joint Distributions, Independent variables

Week 7: Joint Distribution (cont): Conditional distributions, conditional expectation and variance Covariance, Pearson Correlation

Week 8: Functions of several variables: Functions of several variables, sum of variables, expectation of sum of variables

Week 9: Covariance: Variance of sum of variables, covariance, Pearson Correlation

Week 10: Central Limit Theorem: More on the Normal Distribution, **,** t-distribution

Week 11: Estimation: Point Estimator and Confidence Interval estimator

Week 12: Hypothesis testing: H_0, H_1, type I and type II mistakes, power of test

Week 13: Hypothesis testing: of mean when variance is known and unknown, comparing means – paired and independent samples

REQUIRED READING

- Sheldon M. Ross: *A First Course in Probability* Pearson Prenticce Hall, 8th Edition, 2010.
- Bertsekas, Dimitri P. and Tsitsikis, John N., *Introduction to Probability*. Athena Science, 2nd editions, 2008.
- Montgomery, D.C and Runger, G.C. and Hubele, N.F. *Engineering Statistics*. Wiley & Sons, NY, 4th Edition, 2007.

Signals and Systems

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PREREQUESITES: Harmonic Analysis; Circuits and Linear Systems

WAY OF TEACHING: Lectures **=** 3 hours/week; Recitations = 2 hours/week

COURSE TOPICS

Linear Systems: classification, impulse response and convolution

Continuous-time Fourier Series (FS) and Discrete–time Fourier Series (DFS): convergence, Dirichlet conditions, basic properties, Parseval's theorem

Continuous-time Fourier Transform (FT) and Discrete-time Fourier Transform (DTFT), basic properties, inverse transforms

The sampling theorem: Nyquist rate, ideal reconstruction, aliasing and anti-aliasing filtering; non-ideal reconstruction: zero-order, first-order, reconstruction from a finite number of samples

Discrete Fourier Transform (DFT) sampling the DTFT, properties of the DFT, realization of convolution of finate series.

Z-transform: definition, basic properties, the use of the Z-transform for solving difference equations, zeros and poles of the Z-domain transfer function, frequency-response

Digital processing of continuous-time signals: continuous- to discrete-time conversion and vice versa, digital processing of the sampled signal as a substitute for analog processing of the continuous-time signal;

ASSIGNMENTS

Assignments will count for 10% of the total course grade.
7 bi-weekly homework assignments will be given, 6 of which must be handed in for evaluation.
In addition, a Matlab assignment will be given, all of which must be handed in for evaluation.

MIDTERM COURSE POLICY

Midterm exam will count for up to 15% of the total course grade. During an examination, student shall not use books, papers, or other materials not authorized by the instructor. Formula sheets shal be given.

FINAL COURSE POLICY

The final exam will cover the entire course material and will count for 75%/90% of the total course grade. There will be 3 questions (without choice). The duration will be 3 hours. During an examination, students shall only use formulae sheets given by the instructor and a basic calculator. The formulae sheets shall be available at the course' web site from the beginning of the semester.
Students will have a first exam, Moed A. If the student does not pass, he/she can retake the exam, Moed B. The last exam taken will be the student's final grade for the exam.

FINAL COURSE GRADE

10%	- assignments
15%	- midterm exam
75%/90%	- final exam

REQUIRED READING

[1] Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, ***Signals & Systems***, Prentice Hall, 2nd edition, 1997

[2] Alan V. Oppenheim, Ronald W. Schafer, John R. Buck, ***Discrete-Time Signal Processing***, Prentice Hall, 2nd edition, 1999

Electromagnetic Fields

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PREREQUESITES: Harmonic Analysis; Physics 2A; PDE (in parallel)

WAY OF TEACHING: Lectures = 3 hours/week; Recitations = 1 hour/week

COURSE TOPICS

Week 1: Basic concepts in vector analysis in their integral and differential form

-Locationation of the integral representation

-Boundary conditions for Maxwell's equations

Week 2: Statics and Quasistatics

-Introduction: Electrodynamics and plane waves

-Statics

-Quasistatics (slow time variations)

-Examples: Quasistatic capacitor and inductor

Week 3: Electro-statics (ES): Basic principles

-ES equations

-Scalar potential

-The superposition integral

-Poisson's equation

-Green's function

-ES fields in the presence of conductors, capacitance

Week 4: ES problems-solution methods

-Poisson's equation and Laplace's equations

-Characteristics of solutions to the Laplace equation

- -Extremal value theorem
- -The uniqueness theorem
- -The average value theorem

-Method of images

-Solution of boundary value problems in separate systems

-Cartezian coordinates

-Cylindrical coordinates

-Spherical coordinates

-Numerical methods-the average value method, method of moments

Week 5: Polarizability of particles

-The Concept of polarizability: Electric polarizability of perfectly conducting sphere, polarizability of ellipsoids

-The Use of polarizability for the solution of multiple particle problems, inter-particle interaction

-Multi-particle systems, polarization density

Week 6: Conduction

-Physical description

-Steady state currents: Field equations, resistivity

-Various examples

Week 7: Magneto-statics (MS): Basic principles and solution methods

- Field equations

-Vector potential

-Biot-Savart law. Examples for field calculation: loop and coil

-Boundary conditions on a perfect electric conductor

-Solution of MS problems in the presence of sources and boundary conditions: Particular solution and Laplace solution

-The Laplace solution- scalar magnetic potential

-Boundary value problems and images

-Polarizability of particles in magnetic field, comparison to the electric case

Week 8: Polarization

-Sources of the field

-Macroscopic model-polarization charges

-Maxwell’s equations in polarized matter

-State equations in matter

-Various examples

-Polarizability of dielectric sphere

Week 9: Artificial electric materials

-Perfect electric conductor particle arrays

-Dielectric particle arrays

-The influence of inter-particle interactions on the dielectric constant

Week 10: Magnetic field in matter

-Physical sources

-Magnetization density vector

-Macroscopic model for Maxwell’s equation in matter: the magnetic dipole model

-Various examples

-Particle arrays in magnetic field and artificial magnetic materials, Comparison with the electric case.

Week 11: Energy and power flux

-Energy balance in electric networks

-Basic form of conservation laws

-The Poynting theorem

-Stored energy

-Conduction, polarization and magnetization losses (Hysteresis)

REQUIRED READING

- L. M. Magic. *Electromagnetic Fields, Energy and Waves.* Wiley 1972.
- R. E. Collin. *Field Theory of Guided Waves*. Oxford University Press, 2nd edition

Analog Electronic Circuits

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PREREQUESITES: Electronic Devices; Circuits and Linear Systems

WAY OF TEACHING: Lectures = 4 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION

This course introduces the basic principles of analog electronics in context with integrated circuits. It introduces the basic building blocks and simplified analysis techniques

COURSE TOPICS

- Summary of transistor operation with an emphasis on effects relevant to analog circuit design.
- Large and small signal models for diodes.
- Zener diodes and basic diode circuits.
- Large and small signal models of bipolar junction transistors (BJT) at low frequency.
- Field effect transistors (MOSFET, JFET) principle of operation, large and small signal models.
- MOSFET enhancement and depletion transistors.
- Basic amplifier configurations (CE, CB, CC, CS, CG, CD).
- Classification of signal amplifiers by input and output impedances.
- Basic DC current sources, cascode, Widlar and Wilson configurations. Current mirrors and active loads.
- Differential MOSFET and BJT amplifiers (symmetric). Impact of asymmetry on the properties of differential amplifiers.
- Operational amplifiers – ideal and practical.
- Frequency response of amplifier, and extension of the transistor small signal model to higher frequencies.
- Negative feedback analysis, two-port formulation, classification, and impact on the amplifier properties.
- Output (power) stages: A-Class, B-Class, and AB-Class. Power dissipation calculations and design.
- Basic DC power supply circuits with and without feedback.
- Full analysis of 741 operational amplifier.

REQUIRED READING

Main course book:

- S. Sedra, and K. C. Smith, "Microelectronic Circuits", 5th ed., Oxford University Press, 2004.

Secondary:

- P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, "Analysis and design of analog integrated circuits", 4th ed., 2000, John Wiley & sons, Inc

Electronics Lab 1

Return to first page

PREREQUESITES: Electronic devices; Probability and Statistics; Signals and Systems; Analog Electronic Circuits (in parallel)

WAY OF TEACHING: Laboratory = 4 hours/week

COURSE DESCRIPTION

This course is comprised of 9 laboratory experiments. Each experiment is tailored to highlight the most essential measurements and measuring techniques with respect the topic being explored.

The experiments are performed in groups of two and each group is responsible for submitting a *pre-lab assignment* and *lab report*.

The pre-lab assignment is to be completed **before** the experiment and compliments the experiment to be performed.

The lab report is to be completed after the lab; it requires the student to reflect on and discussed the results.

COURSE TOPICS

The Oscilloscope; Transistor characteristics and parameters; Common emitter and emitter-follower configurations; Bias stabilization of transistor amplifiers; Distortions; Common-base amplifier; Characteristics by linear approximation; Clipping circuits.

LAB POLICIES

To be handed out at the start of the semester

Introduction to Control Theory

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PREREQUESITES: Circuits and Linear Systems

WAY OF TEACHING: Lectures **=** 2 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION

This course offers a first introduction to linear control theory, in which the students get acquainted with the concepts of feedback system, tracking error, closed-loop stability, Bode, Nyquist and Nichols plots, PI and PD controllers, empirical tuning, root locus diagrams, gain and phase margin, lead-lag compensators, state space realizations, controllability, observability, stabilizability and detectability, Kalman and Hautus tests, pole placement, elements of linear quadratic optimal control, linear observers and observer-based controllers. It is assumed that the students have some basic ideas about linear systems, transfer functions and the modeling of physical systems.

COURSE TOPICS

Week 1: Linear systems in state space and their transfer function. Stability in the state space and stability in the input-output sense. The Routh test for the stability of a polynomial. The steady state response of a stable system to sinusoidal inputs,examples with DC motors.

Week 2: The concept of feedback and its importance. Classifications of signals and systems. The standard feedback connection of two linear systems, with an algebraic stability test, the reference signal, the disturbance and the tracking error. Proportional and hysteresis control of first order systems.

Week 3: Bode and Nyquist plots, winding numbers, the Nyquist theorem (simple and general version), intuitive explanation of the theorem, examples.

Week 4: Eliminating the steady state error for constant reference and disturbance signals, integral control of first order systems, the behavior of second order systems in terms of natural frequency and damping ratio, some simple root locus plots. Operational amplifiers with feedback loops.

Week 5: PI controllers, empirical tuning rules, anti-windup, eliminating the steady state error for ramp and for sinusoidal reference and disturbance signals.

Week 6: PD controllers, implementation issues, the concept of dominant poles. Root locus plots, with 6 rules.

Week 7: The concepts of gain margin and phase margin, crossover frequency, lead-lag compensators, the use of Nichols charts in controller design.

Week 8: Minimal realizations, the concept of observability, the Kalman and Hautus tests for checking observability (with proofs).

Week 9: The concept of controllability, the duality theorem (with proof), the Kalman and Hautus tests (again), stabilization by state feedback, pole placement (Ackerman's formula), stabilizability. Some elements of linear quadratic optimal control (Riccati equations, synthesis of an optimal state feedback).

Week 10: Observers and dynamic feedback using observers. The separation principle for designing a

REQUIRED READING

- J. D'Azzo, and C. Houpis: *Linear Control System Analysis and Design*, 3rd ed., McGraw Hill, New York, 1988.

ADDITIONAL READING

- R.C. Dorf and R.H. Bishop: *Modern Control Systems*. 9th ed, Addison Wesley, 1995.
- K. Dutton, S. Thompson, B. Barraclough: *The Art of Control Engineering*, Addison-Wesley, Harlow, 1997.
- J. van de Vegte, *Feedback Control Systems*, Prentice-Hall, Inc., London, 1994.

Random Signals and Noise

Return to first page

PREREQUESITES: Introduction to Probability and Statistics, Signals and Systems

WAY OF TEACHING: Lectures = 3 hours/week; Recitations = 2 hours/week

COURSE DESCRIPTION

A course revisiting basic concepts, random variables, vectors and processes as well as Markov chains, Ergodicity, Power spectrum density and LTI.

COURSE TOPICS

Part A: Random Variables and Operations:

Week 1-2: Engineering motivation, probability space, axioms. Revisiting basic concepts for a single random variable. Characteristic function, moments. Functions of random variables.

Week 3-4: Random Vectors: Two random variables-Joint, conditional and marginal distributions. Vectors of random variables. Gaussian vectors.

Week 5-6: Estimation: Optiomal Estimation, error criteria. Minimum mean squared-error (MMSE) estimation. Linear minimum mean squared-error (LMMSE) estimation.

Part B: Random Processes

Week 7: Introduction, definitions and properties. The formation of random processes. Joint distribution, autocorrelation function. Strict-sense and wide-sense stationarity (SSS and WSS).

Week 8: Basic discrete-time and continuous-time processes. Autoregressive process (stationary conditions, Markovity). Random walk, discrete-time white-noise. Gaussian random processes. Wiener process/Brownian motion.

Week 9: Markov chains: Transition matrix, stationary distribution. Characterizing a Markov chains its state diagram.

Week 10: Ergodicity: The law of large numbers. Mean-ergodicity, correlation-ergodicity.

Week 11: Power spectrum density: Definitions, periodogram, continuous-time white-noise.

Week 12-13: Linear Time-invariant (LTI) processing of WSS processes: Joint stationarity of random processes, random processes passing LTI systems. Optimal linear MMSE estimation (Wiener filtering). Multiple-input multiple-output (MIMO) systems. Parallel processing of frequency-bands.

Week 14: Advanced random processes: Poisson process.

Wave transmission

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PREREQUESITES: Electromagnetic Fields

WAY OF TEACHING: Lectures = 3 hours/week; Recitations = 1 hour/week

COURSE TOPICS

PART I: Circuit Theory of Transmission Lines and Distributed Systems

Week 1: A general introduction to wave thewory: different wave types (electromagnetic and others); applications.

Derivation of the transmission line model and of the the Telegraph equations in the time domain. Traveling wave solutions: the concepts of wavespeed and characteristic impedance; voltage and current; power flow; dissipation; energy conservation.

Week 2: Transient solutions in lossless transmission line: reverberations.

Week 3-6: distributed circuit theory in the time harmonic regime: traveling wave solutions and power flow; reflections and standing waves; input impedance. Smith Chart. Measurements in transmission lines. Matching networks: quarter wavelength, stub mating (one two and triple)). Pulse propagation and dispersion: phase and group velocities.

PART II: Electromagnetic Theory of Transmission Lines

Week 7-8: EM waves in transmission line (TEM modes): Review of Maxwell's Equations; derivation of the transmission line model; examples of electromagnetic systems

Week 8-9: EM waves in waveguides: Derivation of the transmission line equations for TE and TM modes in general configurations. Example: rectangular waveguides.

PART III: Plane Waves

Week 10-11: Electromagnetic plane-waves: The wave equation in free space; plane wave solutions; polarization. Plane wave reflection and transmission at in multi-layered media: Transmission line analog. Angular spectrum of plane waves. Radiation from an aperture.

PART IV: Introduction to Radiation

Week 12-13: Radiation: The Herzian dipole. Near vs far fields. Arrays of Herzian dipoles. Far field approximation, radiation patters, interference.

ASSIGNMENTS

There will be 8 homework assignments 75% of all homework assignments must be handed in for evaluation. In addition there will be 4 mandatory MATLAB project that count toward 20% of the final grade. Student will be examined on each project.

MIDTERM COURSE POLICY

The 2 hours midterm will count for 15% of the total course grade, if the mideterm grade is higher than that of the final exam, and will not be counted if the grade is lower. Students are permitted to bring only a basic calculator and 4 pages of formulas (no solved examples) written by the student.

FINAL COURSE POLICY

The final 3 hours exam will cover the entire course material and will count for 65% to 80% of the total course grade, depending if the midterm grade is counted or not. Students are permitted to bring to the exam only a basic calculator and 4 pages of formulas (no solved examples) written by the student.

BIBLIOGRAPHY

1. Sophocles J. Orfanidis, *Electromagnetic waves and antennas*, 2014. Free download from http://www.ece.rutgers.edu/~orfanidi/ewa/
2. S. Ramo, J. R. Whinnery, T. Van Duzer, *Field and waves in communication electronics*, Wiley, 1984
3. U.S. Inan and A.S. Inan, *Electromagnetic waves,* Prentice Hall, 2000.
4. C.T.A Johnk, *Engineering lectromagnetic fields and waves*, Wiley, 1988.
5. R. E. Collin, *Foundations for microwave engineering*, 2nd Edition, McGraw-Hill, 1992 (or Wiley-IEEE Press 2000).
6. D. M. Pozar, *Microwave engineering*, 4th Edition, Wiley 2012 (1st Edition, 1998).

Digital Electronic Circuits

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PREREQUESITES: Digital Logic Systems; Analog Electronic Circuits

WAY OF TEACHING: Lectures = 3 hours/week; Recitations = 1 hour/week

COURSE DESCRIPTION

Digital circuits play a very important role in today's electronic systems. They are employed in almost every facet of electronics, including communications, control, instrumentation, and, of course, computing. This course emphasizes the studying and understanding of basic electronic devices characterization and behavior as switches, the design and analysis of basic electronic circuits consisting MOSFET transistors, and complex circuits such as flip-flops and multi-vibrators. In addition, the use of computer simulation program to analyze digital electronic circuits under their utmost limits.

COURSE TOPICS

Week 1

Review of MOSFET - basic operation and IV curves

Basic inverter, Voltage Transfer Characteristics (VTC), NMOS inverter (Voh and Vol).

Week 2

CMOS inverter:

- Static analysis: VTC, calculation of V_{OH}, V_{OL}, V_{IH}, V_{IL}. Noise margins.

Dynamic analysis - propagation time, rise-time, fall-time, Power-Dissipation-Product (PDP)

Weeks 3

CMOS inverter:

- Dynamic analysis: Calculation of propagation and operational times.

CMOS logic gates: NOR and NAND based technologies. Multiple input and multiple output CMOS design. PUN and PDN synthesis and analysis.

Week 4

CMOS logic gates: Optimal transistor size calculation. Equivalent transistor model.

Z and X states, Introduction to Tri-State devices.

Pseudo-NMOS logic.

Week 5

PTL and TGL: PTL and TGL based design. Voltage and propagation times calculated for PMOS and NMOS based PTL. TGL analysis.

Week 6

Examples of TGL. Dynamic CMOS: Dynamic CMOS design, charge share problem, cascade problem.

Week 7

Dynamic CMOS: domino logic, NP logic.

Flip-Flops: SR-Latch, Metastate, clock enabled latch, D-FF.

Weeks 8-9

Flip-Flops: MS-FF, T-FF, JK-FF, shift-registers, encoders, decoders, clock synchronization and skew problems, PAL and PLA.

Weeks 10-11

A-Stable, Bi-Stable and Mono-Stable Circuits: Schmitt-Trigger, multi-vibrators, op-amp based devices, 555 IC, CMOS based devices, blocking diodes.

Week 12

DAC and ADC: principles, structure, and design: R-ladder, R-2R, flash.

Week 13 (if time permits, we will cover these additional topics)

DAC and ADC: successive approximation, single-slope, dual-slope. Memories: SRAM cell, DRAM cell, ROM, floating gate transistor, Memory architecture, read/write cycles, sense-amplifiers.

SPECIAL REQUIREMENTS

Pspice or EWB software for course assignments and homework.

ASSIGNMENTS

Homework assignments count for **15%** of the total grade. Collaboration is encouraged but you must do your own work! Late homework will not be accepted, unless a special exemption is approved prior to the due date.

MIDTERM COURSE POLICY

A midterm exam will be scheduled in the beginning of the semester. During an examination, student shall not use books, papers, or other materials not authorized by the lecturer. The midterm will count for **20%** of the total course grade.

FINAL COURSE POLICY

The final exam will cover the entire course material and will count for **65%** of the total course grade. Students will have a first exam, Moed A. If the student does not pass, they can retake the exam, Moed B. The last exam taken will be the student's final grade for the exam.

REQUIRED READING

- J. M. Rabaey, "Digital Integrated Circuits", Prentice-Hall, 2002.
- Sedra & Smith "Microelectronic Circuits", 5th Edition, 2004, Oxford University Press.

Electronics Laboratory 2

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PREREQUESITES: Electronics Laboratory 1; Analog Electronic Circuits

WAY OF TEACHING: Laboratory = 4 hours/week

COURSE TOPICS

The students must complete 6 experiments during the 12 lab sessions, while advancing at their own pace. Nevertheless, experiments will be carried out in the following order:

Experiment 1: Operational amplifiers
Experiment 2: Differential amplifiers
Experiment 3: Power supplies and regulators
Experiment 4: Power amplifiers as output stages
Experiment 5: MOS cascode amplifier
Experiment 6: Feedback and stability

LAB POLICIES

To be handed out at the start of the semester

Energy Conversion

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PREREQUESITES: Circuits and Linear Systems; Electromagnetic Fields

WAY OF TEACHING: Lectures **=** 3 hours/week; Recitations = 1 hour/week

COURSE TOPICS

Week 1-3: Three-Phase power system: Voltages, currents, power in a symmectric network, phasor diagrams magnetic circuits: Linear and non-linear magnetic circuits in direct and alternating currents, hysteresis and adds current losses, flux leakage, magnetic coupled circuits, forces.

Week 5-6: Transformer: Single and three-phase transformer structure, equivalent circuit, losses, efficiency, no-load and short circuit tests, voltage regulation.

Week 7-8: Induction Machine: Structure, rotating magnetic field, equivalent circuit, powers, losses, efficiency, speed-torque characteristics, starting, speed regulation.

Week 9-10: Solar Cell Systems: Properties, I-V characteristics, operating point, series and parallel connections, photovoltanic arrays, load I-V characteristics, maximum power point tracker.

Week 11-12: Direct Current Machine: Generators and motors in separate, shunt, series and compound excitations, structure, e.m.f. torque, power, losses, efficiency, generator load characteristics, motor mechanical characteristics, motor speed regulation.

Week 13: Converter: Basics of dc converters.

REQUIRED READING

TBA

Project

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PREREQUESITES: No

WAY OF TEACHING: Laboratory = 6 hours/week (semester 7) and 2 hours/week (semester8)

COURSE DESCRIPTION

The purpose of the project is to practice your performance in the field of Electrical Engineering. Tutors are the staff of the Faculty or Engineerings active in the Industry. The project begins, as is customary in the industry, with the definition of a problem and ends with the design specification, development and testing.

SCOPE OF PROJECT

Student must work 350 hours**.**

PROJECT TEAM WILL:

-Study the overall problem

-Find a possible resolution method

-Choose the appropriate method and explain the choice

-Carry out the detailed design of the system

-Implement the system

-Ensure that the system operates in accordance with the requirements set forth

WORKING METHOD

Work is mostly independent and carried out by two teams of students under the direction and guidance of the supervisor. Each facilitator will have set hours during which students will receive office hours.

PROGRESS REPORTS

Progress reports are required for each team to submit.

1. The workplan includes a job description and summary of the project timetable. The report is to be prepared 1 month after the start of the academic year
2. The first monitoring report is a summary of the progress of the first semester
3. The second monitoring report is a conclusion of the second semester of the year. At this time a deadline is set for submission of the project

These reports are an integral part of the work.

PROJECT COMPLETION AND SUBMISSION

Once project is completed, the team presents it to the supervisor and academic staff. The length is twenty minutes with five minutes for discussion. The presentation should include slide presentation and demo project in action. The project team must also submit:

1. Project completion report
2. A poster detailed the concised and focused explanation of the project

Project deadline is at the latest two weeks before the start of the following school year (for students starting the project in the first semester). Students have a year from project start to complete project.

Students can registere for the project starting from the completion of the sixth semester and upon an academic meeting with the supervisor regarding completion of the first six semesters of the program in good academic standing. Project approval will be given upon completion of registration.

Details of the project proposals, application process, student tasks and milestones can be provided by the International B.Sc program office.

Electronics Laboratory 3

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PREREQUESITES: Electronics Laboratory 2, Digital Electronics Circuits

WAY OF TEACHING: Laboratory = 4 hours/ week

COURSE OBJECTIVES

The objective of this laboratory is two-fold : 1. To design and build fundamental digital electronic circuits and perform rigorous experiments to consolidate basic knowledge in digital electronics; 2. To provide the student with the know-how required to use modern electronic instrumentation.

LABORATORY MODULES

Basic integrated circuits; counters; decoders; multiplexers and de-multiplexers; bi-stable, mono-stable and a-stable circuits; shift registers; memory components; A/D and D/A converters. In addition, an FPGA project is carried out to consolidate basic knowledge acquired during the lab meetings.

REQUIRED READING

Digital Electronics Laboratory Manual-Tel Aviv University

Relevant data sheets

LAB POLICIES

To be handed out at the start of the semester

Energy Conversion Laboratory

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PREREQUESITES: Energy Conversion; Power Electronics (in parallel)

WAY OF TEACHING: 3 Labs

LABORATORY MODULES

1) Single phase transformer: no load, short circuit and load experiments, operating two transformers in parallel.
2) DC Machine: separated and parallel excitation of a DC generator and DC motor
3) Induction machine: no load, short circuit and load experiments, operating an AC machine as a generator, speed control by resistors and by frequency controller.
4) High frequency DC-DC converters: step down (buck) and step up (boost) converters.
5) Photovoltaic Cells: i-v characteristics in both regular and under shading conditions, parallel and serial connections, operating solar panel in both direct connection to the load and by maximum power point tracker system.

LAB POLICIES

To be handed out at the beginning of the semester

Introduction to Digital Signal Processing

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PREREQUESITES: Signals and Systems

WAY OF TEACHING: Lectures = 3 hours/week; Recitations = 1 hour/week

COURSE TOPICS

Week 1-2: The Z transform, review and extensions. Pole Zero and region convergence(ROC) analysis, relation to stabitlity and causality. Inverse Z transform. Transform analysis of linear time invariant (LTI) systems. Minimum phase systems.

Week 3-4: Discrete time processing of continuous time signals, review and extensions. Sampling rate conversions. Polyphase decompositions.

Week 5-6: Design of digital filters. Design of infinite impulse response (IIR) filters from analog filters. Design of finite impulse response (FIR) filters, windows and frequency sampling. Linear phase filters. Optimal (minimax) design of FIR filters.

Week 7-8: Discrete Fourier series (DFS). Dsicrete Fourier transform (DFT). Circular convolution and linear convolution using the DFT.

Week 9-10: The fast Fourier transform (FFT) for fast calculation of the DFT. Decimation in time and decimation in frequency (FFT). The goertzel algorithm. The chirp transform algorithm.

Week 11-12: The discrete cosine transform (DCT).

Week 13-14: Spectral analysis using short time Fourier transform.

REQUIRED READING

TBA

Communication Systems

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PREREQUESITES: Random Signals and Noise

WAY OF TEACHING: Lectures = 3 hours/week; Recitations = 1 hour/week

COURSE TOPICS

Week 1: Introduction, communication systems' configuration, basic principles and main properties for frequency-domain analysis, the Fourier transform of a deterministic signal vs. the spectrum of a stationary random process, cyclostationarity.

Part A, Weeks 2-8

Pulse Coding Modulation (PCM), Pulse Amplitude Modulation (PAM); Quantization and quantization noise; Basic digital modulation methods; Transmission in an Additive White Gaussian Noise (AWGN) channel, a matched filter; Inster-Symbol Interference (ISI) and eye-diagrams; Delta modulation.

Part B, Weeks 9-14

Bandpass signals and their representations; Narrow band noise.

Amplitude modulations (definition, implementation, detection, analysis): Amplitude Modulation (AM), Double-Side Band Suppressed Carrier (DSB-SC); Single-Side Band (SSB) modulation, Hilbert transform;

Angle modulations (definition, implementation, detection, analysis): Phase Modulation (PM), Frequency Modulation (FM), Narrow-Band FM.

ASSIGNMENTS

Weekly homework assignments to be handed in for evaluation within two weeks, after which solutions would be published.

MIDTERM COURSE POLICY

A midterm exam will be scheduled in the beginning of the semester. During an examination, student shall not use books, papers, or other materials not authorized by the instructor. The midterm will count for 10% of the total course grade, and will be based on problems that appeared in the lectures, recitations and HW assignments.

FINAL COURSE POLICY

The final exam will cover the entire course material and will count for 90% of the total course grade.

Students will have a first exam, Moed A. If the student does not pass, they can retake the exam, Moed B. The last exam taken will be the student's final grade for the exam.

REQUIRED READING

TBA

Practical Feedback Systems

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PREREQUESITES : Introduction to Control Theory

WAY OF TEACHING : Lectures= 3 hours/week ; Recitations= 1 hour /week

COURSE DESCRIPTION

The course covers advanced topics of modern control engineering in the frequency domain and the control of nonlinear feedback systems. The course topics include: Characterization of control systems, components in control systems, DC motors and their models, PID design of feedback control systems, limitations of feedback in non-minimum phase and unstable systems, introduction to robust feedback design of single-input single-output systems, non-linear feedback, describing functions, phase plane trajectories, the isocline method, PLL circuits, frequency and phase tracking

COURSE STRUCTURE

Week 1: Advanced loop shaping technique, input and output disturbance rejection, sensor noise attenuation, the meaning of control effort and open-loop and closed loop bandwidth with application to servo control.

Week 2: Advanced PID control and its relation to first-order compensation networks. Design using pole-placement technique, practical PID controllers.

Week 3: Non Minimum Phase (NMP) control systems and the concept of positive control systems, Unstable systems, limitations of open-loop and closed-loop bandwidth of both types, The concept of undershoot of step response of NMP systems.

Week 4: PID tuning techniques, Ziegler-Nichols' open loop method, Ziegler-Nichols' closed- loop method , The Zigler Nichols tuning rules, Improved tuning techniques, demonstration on servo systems.

Week 5: Nonlinear systems, the concept of Describing Function (DF), derivation of the DF for various nonlinear control devices. Limit Cycles (LC) and their meanings.

Week 6: Nonlinear systems, graphical and computational techniques for probing LC using the DF approximation, stability of LCs using the Nyquist stability criterion, application to servo control.

Week 7: Nonlinear Systems, The concept the phase-plane , application to the ZIR and ZSR of linear systems, the isocline method, phase portraits and system trajectories, stable focus, unstable focus, vortex and saddle point descriptions.

Week 8: Nonlinear Systems, application of the phase plane to simple nonlinearities, the saturation and linear plant combination, singular points and Poincare-Bendixon Theorem, application to servo systems.

Week 9: Time delay control systems, limitation of bandwidth, the Pade approximation, deterioration of performance.

Week 10: DC motor servo control models, first and second order approximations, electrical and mechanical time constants, Dc motors with flexible loads, resonance and anti resonance.

Week 11: Application of control theory in communication networks: The Phase Locked loop (PLL) circuit, linear and nonlinear models, frequency and phase tracking, high order PLL circuits, application to servo control systems.

ASSIGNMENTS

The homeworks will constitute 10% of the total course grade.

FINAL EXAM POLICY

The final exam (two opportunities) will cover the entire course material and will count for 90% of the total course grade. The duration will be 3 hours. Students will have a first opportunity exam and a second opportunity exam. The exam mark for the course will be the mark obtained for the last exam taken by the student for this course.

REFERENCES

- Katsuhito Ogata, "Modern Control Engineering", Prentice Hall, 5th edition, 2010.
- Richard C. Dorf, Robert H. Bishop, "Modern Control Systems", Prentice Hall, 12th edition, 2011.
- Jean-Jacques E. Slotine, Weiping Li, "Applied Nonlinear Control", Prentice Hall, 2nd edition, 2004.

Introduction to Operating Systems

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PREREQUESITES: Data structures and algorithms; Programming in C; Digital Logic systems

WAY OF TEACHING: Lectures= 3 hours/week; Recitations= 1 hour/week

COURSE TOPICS

Instruction Set Architecture. Computer Arithmetic. The Processor. Cache. Processes and Threads. Deadlocks. Memory Management. File Systems. Input/Output.

REFERENCES

- David A. Patterson, John L. Hennessy, "Computer Organization and Design", Morgan Kaufman Pub., 5th edition, 2014
- Andrew S. Tanenbaum, Herbert Bos, "Modern Operating Systems", Pearson, 4th edition, 2014
- Remzi H. Arpaci-Dusseau, Andrea C. Arpaci-Dusseau, “Operating Systems: Three Easy Pieces”, Arpaci-Dusseau Books, version 0.90, March 2015. Available Online: http://pages.cs.wisc.edu/~remzi/OSTEP/

GRADING

Requirement	**Details**	**Grade percentage**
Homework exercises	Must submit 7 out of 8 exercises. The best 7 will be used for grading.	15%
Midterm		25%
Final exam		60%

DETAILED TOPICS

Introduction to CS

Computer Structure introduction: History of computers. Classes of Computers. Computer Hardware Review. Moore’s law. Power trends. Flynn’s Taxonomy. Amdahl’s Law. CPI and the processor performance equation. Integrated circuit cost.

Instruction Set Architecture

Operations. Operands. Signed and Unsigned Numbers. Encoding Instructions. Logical Operations. Branches. Addressing Modes. Procedures. Subroutines. Stack. Compiler. Assembler. Linker. DLL. RISC vs CISC.

Computer Arithmetic

Addition. Subtraction. Multiplication. Division. Floating Point.

The Processor

Datapath: PC, ALU, Registers, Mux. Control: Micro-coded and Hard-wired. Single Cycle Implementation. Pipelining. Classic 5-stage RISC pipeline. Structural Hazards. Data Hazards. Control Hazards. Resolving Hazards: Stalling, Forwarding.

Cache
The memory hierarchy. Structure and operation of a direct mapped cache. Cache performance modeling equations. Associative caches. Replacement algorithms. Write policy. Multilevel caches. Software optimizations.

Introduction to OS
Operating Systems introduction: History of OS. Classes of OS. Concepts: Processes, Address Spaces, Files, I/O, Protection, The Shell. System Calls. OS structure.

Processes and Threads
The Process: Model, Creation, Termination, Hierarchies, States, Implementation, Modeling Multiprogramming.
The Thread: Usage, Classical Model, POSIX Threads. Implementation: User Space, Kernel Space, Hybrid. Scheduler Activations. Pop-Up Threads. Making Single-Threaded Code Multithreaded.
Interprocess Communication: Race Conditions. Critical Regions. Mutual Exclusion with Busy Waiting. Sleep and Wakeup. Semaphores. Mutexes. Monitors. Message Passing. Barriers. Avoiding Locks: Read-Copy-Update.
Scheduling: Batch Systems. Interactive Systems. Real-Time Systems. Policy vs Mechanism. Thread Scheduling.
Classical IPC Problems: The Dining Philosophers. The Readers and Writers.

Memory Management
Early computers. Address spaces abstraction: Swapping, Managing Free Memory.
Virtual Memory: Paging, Page tables, Speeding Up Paging, TLB, Page Tables for Large Memories.
Page Replacement Algorithms: Optimal, Not Recently Used, FIFO, Second-Chance, Clock Page, LRU, Working Set, WSClock.
Design Issues: Local vs Global Allocation. Load Control. Page Size. Separate Instruction and Data Spaces. Shared Pages. Shared Libraries. Mapped Files. Cleaning Policy. Virtual Memory Interface.
Implementation Issues: OS involvement. Page Fault Handling. Instruction Backup. Locking Pages. Backing Store. Separation Policy and Mechanism.

File Systems
Files: Naming. Structure. Types. Access. Attributes. Operations. File System Calls.
Directories: Single Level. Hierarchical. Path Names. Directory Operations.
Implementation: Layout. Files. Directories. Shared Files. Log Structured FS. Journaling FS. Virtual FS.
Management and Optimization: Disk Space. Backups. Consistency. Performance. Defragmenting Disks.
Examples: MS-DOS, Unix V7, CD-ROM.

Input/Output
Hardware: Devices. Controllers. Memory Mapped I/O. Direct Memory Access. Interrupts.
Software: Goals. Programmed I/O. Interrupt-Driven I/O. I/O Using DMA.
I/O Software Layers: Interrupt Handlers. Device Drivers. Device Independent I/O. User Space I/O Software.
Disks: Hardware. Formatting. Arm Scheduling Algorithms. Error Handling. Stable Storage.
Clocks: Hardware. Software. Soft Timers.
User Interfaces: Keyboard, Mouse, Monitor, Input/Output Software.

Deadlocks
Resources: Preemptable. Nonpreemptable. Acquisition. Condition for Resource Deadlocks. Deadlock Modeling. The Ostrich Algorithm. Deadlock Detection. Deadlock Recovery. Deadlock Avoidance: Resource Trajectories, Safe and Unsafe States, The Banker's Algorithm. Deadlock Prevention. Other Issues: Two-Phase Locking. Communication Deadlocks. Livelock. Starvation.

Case Study: The Linux OS
Unix History. Overview. Processes. Memory Management. Input/Output. File System. Security.

Introduction to VLSI Design

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PREREQUESITES: Digital Logic Systems; Electronic Devices

WAY OF TEACHING: Lectures= 3 hours/week; Recitations= 1 hour/week

COURSE DESCRIPTION

This course is an introduction to VLSI design with focus on CMOS process and digital design. It provides an overview of VLSI design techniques and tools used by the chip design industry.

COURSE TOPICS

1. Introduction: CMOS gates, memories analog and mixed signal circuits, examples.
2. MOS transistor review: models, static gates, transmission gates, tristate, domino logic, logic families
3. CAD tools for VLSI: Cadence Schematics, Layout and SPECTRE simulation
4. VLSI fabrication/process review: fabrication steps, DRC – design rules check to ensure manufacturability
5. Preliminary design: parameter evaluation, parasitic RC estimation, rise and fall times, delay and power estimation. Sizing, design margin, reliability and scaling.
6. CMOS circuit design: logic selection, timing, IO circuits, low power design
7. Design Strategies and Options: standard cells, gate arrays PLD, symbolic design, design verification
8. Data Path and ALU examples: Adders, multipliers, muxes and hierarchical design
9. Chip Design examples: subsystems, examples for DSP, memories (static, dynamic, FLASH) and processors

REFERENCES

1. Digital Integrated Circuits, a Design Perspective – Rabaey, Jan M.; Chandrakasan Anantha; Nikolic, Borivoje; 3rd edition Prentice Hall, 2014 – **course textbook**

2. On-line Cadence documentation available on TAU workstations

2. Tel Aviv University VLSI Lab WEB page : http://www.eng.tau.ac.il/research/laboratories/VLSI_lab/index.pdf

3. NCSU EDA Wiki http: //www.eda.ncsu.edu/wiki/Tutorial:Contents

4. Berkeley VLSI Intro site : http://bwrcs.eecs.berkeley.edu/Classes/icdesign/ee141_f12/

5. Technion VLSI Lab : http://webee.technion.ac.il/vlsi/

Power Electronics

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PREREQUESITES: Introduction to Control Theory, Energy Conversion

WAY OF TEACHING: Lectures= 3 hours/week ; Recitations= 1 hour/week

COURSE DESCRIPTION

In this course the student will learn basic circuits for high efficiency power conversion: dc-dc switched mode converters, rectifiers, and inverters. In addition to operation principles the student will aquire basic design capabilities.

COURSE TOPICS

Switched mode power converters: Ideal of dc-dc converters in steady state, Loss mechanisms in dc-dc converters, Dynamics of dc-dc converters, and design of closed loop control.
Line frequency diode based rectifiers, thyristors' based rectifiers, and switched mode rectifiers.
Single phase and three phase quasi sinusoidal and real sine inverters.

REFERENCES

1. S. J. Chapman, *Electric Machinery Fundamentals* McGraw-Hill Inc.
2. R. W. Erickson, *Fundamentals of Power Electronics*, 1st and 2nd editions.

RF Circuits and Antenna

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PREREQUESITES: Wave transmission

WAY OF TEACHING: Lectures **=** 3 hours/week; Recitations = 1 hour/week

COURSE TOPICS

A. Microwave section:

A.1 Waveguide theory: basic modal theory, review of the rectangular waveguide.

A.2 Microwave networks: *Z, Y* and *S*-parameters (option: ABCD and cascading).

A.3 Examples of other waveguides: dielectric slab, fiber optics, microstrip.

A.3 Impedance matching and instrumentation: matching techniques, operation of the Network Analyzer.

A.4 Review of low and high power microwave sources.

B. Antenna section:

B.1 The radiation integral: review of the wave equation, potentials, free space Green's function and the radiation integral, the far field concept, energy conservation in the far field, elementary radiators.

B.2 Parameters of antennas in transmit mode: intensity, radiation pattern, directivity, efficiency, gain, radiation resistance, input impedance and matching, polarization states.

B.3 The antenna in transmit – receive systems: effective length, effective aperture, polarization mismatch, the Frijs equation.

B.4 Wire antennas: short dipole and half-wavelength dipole.

B.5 Propagation: interference with perfect ground, fading. Over the horizon propagation, ionosphere.

B.6 Introduction to linear antenna arrays: principle of pattern multiplication, linear array factor, linear array grating lobes. Examples of uniform and tapered distributions.

REQUIRED READING

- R. E. Collin, *Foundations for Microwave Engineering*, 2nd Edition, Wiley-IEEE Press 2000.
- M Pozar, *Microwave Engineering*, 4th Edition, John Wiley & Sons, 2012
- W. L. Stutzman and G. A. Thiele, *Antenna Theory and Design*, John Wiley & Sons, 2012
- A. Balanis, *Antenna Theory: Analysis and Design*, 3rd Edition John Wiley & Sons, 2005

Signal Processing Lab

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PREREQUESITES: Digital Signal Processing

WAY OF TEACHING: 5 Labs of 3 hours each

COURSE DESCRIPTION

In this lab, the students will implement Signal Processing algorithms in real-time using an FPGA (Zynq by XILINX).

COURSE TOPICS

The lab comprises the following experiments:

Lab 1: Introduction to the Development Environment and Basic Signal Processing Operations
Lab 2: Digital Filters and sinewave generation
Lab 3: Adaptive Filtering
Labs 4 and 5: Spectral Analysis (FFT)

REQUIRED READING

TAU Signal Processing Lab handouts **-** This material is self-explanatory, and contains the theoretical background as well as the experiments' guidelines

ADDITIONAL READING

The Zynq Book website - http://www.zynqbook.com/

Communication Lab

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PREREQUESITES: Communication Systems

WAY OF TEACHING : 7 Labs of 3 hours each

COURSE DESCRIPTION

In this lab the students will be able to understand basic communication techniques. The experiments are based on the TIMS platform. In each experiment the students, will build implement the system, and check its performance.

COURSE TOPICS

The following topics by the lab experiments:

Lab 1: Introduction
Lab 2: Spectrum Analyzer
Lab 3: Sampling
Lab 4: Pulse Code Modulation (PCM)
Lab 5: Amplitude Shift Keying (ASK)
Lab 6: Amplitude Modulation (AM)
Lab 7: Frequency Modulation (FM)

Control Laboratory

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PREREQUESITES: Introduction to Control Theory

WAY OF TEACHING: 4 Labs of 4 hours each.

COURSE DESCRIPTION

The purpose of this course is to bridge the gap between mathematical aspects and practical implementation of control systems. First session will be devoted to control-oriented practice of Matlab & Simulink.
Lab experiments: Position control, Velocity control, Ball and tray stabilization.

COURSE TOPICS

- Open and closed loop responses of 1st and 2nd order transfer-functions.
- Proportional, Integral and Derivative (PID) controller design.
- Implementation of lead/lag compensators.
- State-Space representation of dynamic systems.
- Control laws and signal transformation.
- Analysis of Bode diagrams.

REQUIRED READING

Any relevant information will be given via laboratory briefing.

GRADING

Coursework will be weighted as follows:
Preliminary reports (total of 4) - 30%
Final reports (total of 4) - 40%
PID exercise - 10%
Participation - 20%

LAB RULES

- Do not damage the lab equipment.
- No food or drinks allowed apart from drinking water in safe distance from lab equipment.
- Phones should stay in the backpack during lab hours. You can make a phone call outside.
- All backpacks most be stored in the designated closet.
- Do not rename, delete or change the original experiment files – create a new copy of the file, rename it and use it for the experiment.
- Leave your work area clean and shut down the computer.
- Unjustified absences will result in 0 grade in the experiment.
- The students MUST read the instructions before the experiment and understand it. The participation portion of the final grade will be heavily based on the student familiarity and knowledge of the experiment in the lab.

SUBMISSION RULES

- Any unjustified delay in submission will result in penalty of 5 points per day and in the case of preliminary report, penalty of 20% of the experiment grade.

Reports

- All reports should be submitted by email to Peleabit@mail.tau.ac.il with title of the following format: <pre/final>_<experiment name>_<id # 1>_<id #2>.
  Example: "Pre_Velocity control_12345678_11235813".
- The preliminary report will include the answers to the preliminary section in the lab instruction.
- Reports should include explanations, graphs, drawings, block diagrams and calculations.
- In the final report, if there is a mismatch between the theory and the results, suggest s possible explanation and description of the result the theory is predicting.

PID exercise

- Should be submitted by email to Peleabit@mail.tau.ac.il with title of the following format: PID_<id # 1>_<id #2>.
- Must be submitted before the second session.

COMMUNICATION

For any question or problem please contact the instructor by mail or moodle.
Reception hours are dynamic, contact the instructor to coordinate if needed.

Computer Structure Lab

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PREREQUESITES: None

WAY OF TEACHING: Laboratory= 12 meetings of 3 hours; Recitation= 7 meetings of 2 hours+ 3 meetings of 3 hours

COURSE DESCRIPTION

Introduction to computer aided hardware design and simulation. Design, implementation and hadware debug of a simple RISC processor using targed FPGA board. Acquaintance with basic components of the computer structure: main memory, main bus, bus protocol.

COURSE TOPICS

Topic 1: 2 Recitations and 2 Lab meetings

- Introduction to Computer aided hardware design and simulation.

- How to use the Xilinx software (ISE v14.7) to prepare hardware designs and how to test the correctness of designs (i.e. simulation).

- Logical structure of the educational RESA Computer (board with XILINX FPGA) with their buses and protocols. Read and Write transactions over the bus. Design and simulation of the CPU bus interface.

Topic 2: 2 Recitations and 3 Lab meetings

- Introduction to the RESA board architecture. How to create a configuration file for the FPGA (i.e. implementation). How to run the RESA monitoring program and using it to configure FPGA, upload program codes and debug the design.

- Design and simulation of Simple slave device. Implementation and hardware debugging of the design using RESA Computer (target FPGA board and monitoring program).

- Design and simulation of Hardware Monitor, consisting of Simple slave, ID and Build-in Logic analyzer. Design implementation and hardware debugging using RESA Computer.

- Analyzing the monitoring results for every stage.

Topic 3: 3 Recitations and 7 Lab meetings

- Read and Write transactions to the External Memory. Design, simulation and implementation of Read and Write machines. Debug the designs using previously designed Hardware Monitor with Logic analyzer.

- Design of Load/Store machine with Control and Data Path. Simulation of the Control using test vectors. I/O Simul structure and initialization data. Assembly Compiler and CPU Simulator. How to use the I/O Simul to simulate and debug the RTL and whole instructions. Implementation and debug of the Load/Store Machine with RESA Computer.

- Design and simulation of Simplified RISC CPU. Writing short test programs in assembly and update the initialization data of I/O Simul. Implementation and debug of the CPU using your test programs. Final QA with ready CPU test program. Timing issues and optimization. Write an assembly program, that solves a problem, and run it on the CPU you designed.

REQUIRED READING

www.eng.tau.ac.il/~marko

VLSI Lab

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PREREQUESITES: Digital Logic Systems; Electronic Devices; VLSI course in parallel

WAY OF TEACHING : 6 Labs of 2 hours each

COURSE DESCRIPTION

This lab is given in parallel to the VLSI Intro course and is tightly linked to it. The goal is to enhance the learning experience of the course by providing hands-on experience on industrial tools and using those tools to implement circuits related to course topics.

COURSE TOPICS

Lab 1: Introduction to Cadence Virtuoso for Schematics and Cadence ADE-L for circuit simulation. Designing a CMOS inverter. Introduction to layout.
Lab 2: Layout of inverter and additional logic gates, extraction of parasitics from the layout and layout-based circuit simulation. Interconnect design.
Lab 3: Logic families, with emphasis on static CMOS versus Dynamic/Domino, Sequential cells design, setup/hold measurement
Lab 4: Logic design and simulation of simple ALU
Lab 5: Continued design and simulation of simple ALU, floor plan.
Lab 6: Layout and verification of simple ALU

REFERENCES

1. On-line Cadence documentation available on TAU workstations
2. Tel Aviv University VLSI Lab WEB page :
http://www.eng.tau.ac.il/research/laboratories/VLSI_lab/index.pdf
3. NCSU EDA Wiki http: //www.eda.ncsu.edu/wiki/Tutorial:Contents
4. Berkeley VLSI Intro site : http://bwrcs.eecs.berkeley.edu/Classes/icdesign/ee141_f12/
5. Technion VLSI Lab : http://webee.technion.ac.il/vlsi/

Power Electronics Lab

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PREREQUESITES: Energy Conversion, Energy Conversion Laboratory

WAY OF TEACHING: Experiments in groups of 2-3 students with lab instructors

COURSE DESCRIPTION: The course aims to give practical experience in general power electronics and power electronics for renewable energy. The students will experiment in practical DC/DC converters including the various applications in power electronics.

COURSE TOPICS:

- Solar energy: Single solar cell and module characteristics and shadowing effect. Loading of solar modules by typical loads such as passive loads, DC motors and batteries. Maximum power point tracking (MPPT).
- High frequency DC/DC converters: Basic passive components and switching devices. Operation and characteristics of Buck, Boost and Flyback converters in steady state under open loop control. Output regulation by means of closed loop control (two meetings).
- Phase controlled line frequency rectifiers, design and application area.

REFERENCES

1. Advanced energy conversion Lab. manual.

2. "Fundamentals of power electronics", R. W. Erickson, Chapman & Hall, NY 1997.

Microwave and Radiation Laboratory

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PREREQUESITES: RF Circuits and Antennas

WAY OF TEACHING: 4 Labs of 3 hours each

COURSE TOPICS

Lab 1: Transmission-lines and waveguides
Lab 2: Impedance measurements and impedance-matching techniques
Lab 3: Microwave components and devices
Lab 4: Antennas and radiation

COURSE POLICIES

• A preparation study is required prior to each meeting, as instructed in the laboratory guide booklet.

• A brief quiz shall be passed at the beginning of each laboratory meeting.

• The technical work is conducted at this laboratory by teams of two students each.

• The laboratory reports are individually prepared and submitted by each student.

• Each student is responsible for the safety of her/his actions in the laboratory (regardless of the University liability).

• Careful workmanship is required (in particular with the expensive equipment).

REQUIRED READING

1. The Microwave Laboratory Experiment Instructions. (available online).
2. R. E. Collin, Foundations for Microwave Engineering, Wiley-IEEE Press 2000.
3. M. Pozar, Microwave Engineering, Wiley 2012.
4. W. L. Stutzman and G. A. Thiele, Antenna Theory and Design, Wiley 2012.
5. A. Balanis, Antenna Theory: Analysis and Design, Wiley 2005

PREREQUESITES: No

WAY OF TEACHING: Lectures = 3 hours/week

COURSE OBJECTIVES

The purpose of this course is to learn and practice the latest theories and models on entrepreneurship from academia and the industry best practice, to develop an understanding of those principles and models through the examination of case studies, as well as to provide the practical hands-on skills and knowledge necessary to transform a promising idea into a successful reality.

COURSE REQUIREMENTS

Students will be required to study the underlying theories that drive modern-day entrepreneurship and to display an understanding and ability to analyze case studies. Furthermore every participant will engage in the creation of a start-up, openly discuss their ideas and share their opinions with the group. The course is about building skills and ability, not only obtaining knowledge about start-ups.

Students will form work-groups which will develop an entrepreneurial business plan. The assessment in this course will be based on the implementation of the theories, models and best-practices learnt in the class, as portrayed in a group presentation and business plan. The final grades will be based on the following allocation:

30% In-class presentation
70% Working paper – business plan

Methods of learning

Through reading material and lectures, the course will expose students to pioneering methods from academic research, experienced entrepreneurs. Students will engage in implementation of the various theories of entrepreneurship and start-ups. Each participant will take part in the formation of a start-up, including the practice of each and every skill required to found a new and innovative company.

Methods and theories discussed

Innovation plays an essential role in today's business arena, and is vital not only for start-up companies but also for growth and survival of established organizations. For that reason, a good understanding of the entrepreneurship process is important not only for entrepreneurs, but for corporate employees - allowing them to recognize the "big picture" from the owner's perspective and to evaluate and act upon new opportunities for the firm.

This course will provide a practical, real-world knowledge and methods that will enhance knowledge and abilities in the following topics:

"The idea"

- Finding a need and evaluating an idea.
- Devising an effective business plan, presentation and "elevator pitch"
- Characterizing a project.
- Creating value and capturing value.

Audia, P. G., & Rider, C. I. (2005). A garage and an idea: what more does an entrepreneur need?. *California Management Review*, *48*(1), 6.

Market

- Identifying market needs, growth and trends.
- Understanding the market
- Identifying the market players, their motivation and strategy.

Choi, Y. R., & Shepherd, D. A. (2004). Entrepreneurs' decisions to exploit opportunities. *Journal of Management*, *30*(3), 377-395.

People and the Team

- Team building and role assignment. Recruiting employees and investors.
- Identifying distribution channels and business partners.

Hmieleski, K. M., & Ensley, M. D. (2007). A contextual examination of new venture performance: entrepreneur leadership behavior, top management team heterogeneity, and environmental dynamism. *Journal of Organizational Behavior*, *28*(7), 865-889.

Interpersonal Communication

- Communicating a vision in one-on-one talks and presentations. Negotiation.
- Building a demo.

Chen, X. P., Yao, X., & Kotha, S. (2009). Entrepreneur passion and preparedness in business plan presentations: a persuasion analysis of venture capitalists' funding decisions. *Academy of Management Journal*, *52*(1), 199-214.

Strategy Models

- Creating value through lowering the uncertainty factor in a venture (lean start-up method and more). Pros and cons of common business models
- Web-generated user base management models

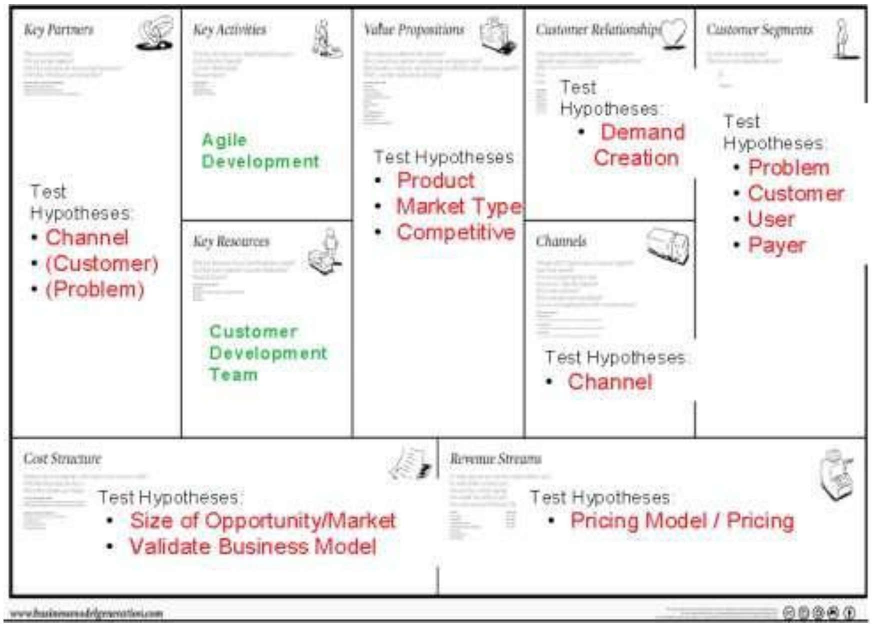
Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*. Wiley. com.
Chesbrough, H. (2007). Business model innovation: it's not just about technology anymore. *Strategy & leadership*, *35*(6), 12-17.

Management Throughout the Life-cycle

- Soflt launch and in-motion product improvement
- Management strategies at various company lifecycle stages
- Product improvement through A/B testing and measurement

Avnimelech, G., & Teubal, M. (2006). Creating venture capital industries that co-evolve with high tech: Insights from an extended industry life cycle perspective of the Israeli experience. *Research Policy*, *35*(10), 1477-1498.

See below an excerpt from Steve Blank's *Business Model Generation*



<u>Additional Reading Material</u>

The course material will include ideas and theories from the following sources:

Ries, E. (2011). *The Lean Startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Random House Digital, Inc..

Blank, S. G., & Dorf, B. (2012). *The startup owner's manual: the step-by-step guide for building a great company*. K&S Ranch, Incorporated.

Collins, J., & Porras, J. I. (2004). *Built to last: Successful habits of visionary companies*. HarperCollins.

Collins, J. (2001). *Good to great: Why some companies make the leap... and others don't*. HarperCollins. Covey, S. R. (2011). *The 7 Habits of Highly Effective People*. Enterprise Media.

Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*. Wiley. com.

FOUNDATIONS OF ENTREPRENEURSHIP

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PREREQUESITES: Entrepreneurship 1

WAY OF TEACHING: Lectures = 3 hours/week

COURSE OBJECTIVES

The course is intended to provide approaches and tools for generating, validating and presenting entrepreneur ideas. It will focus on principles and basic concepts in entrepreneurship and intra-preneurship including theoretical aspects based on research and practical terms and real examples from the Israeli start-up nation and global arena.

COURSE DESCRIPTION

The course will include some fundamentals regarding the entrepreneurial process and how to establish new business, business plan – purpose and structure, financial aspects of start-ups, entrepreneurship within organizations, social entrepreneurship, design thinking, presentation skillset, reasons for success and failures of entrepreneurs.

LECTURE APPROACH

The course will combine frontal lectures (also by guest lecturer), students' discussion, workshops and presentations.

COURSE REQUIREMENTS

We expect full attendance in the course, preparation of reading material, presentation of interviewed start-up and a summary of the interview, examination at the end of the course.

GRADES

Course attendance – 15%

Mid-term presentation – 25%

Exam – 60%

Week	Topic	Comments/Workshops
1	Introduction to Entrepreneurship, type of Entrepreneurships, GEM – Global Entrepreneurship Monitor	Introductions, course description and the process
2	- Marketplaces - The Business Plan and Business Model Canvas	With Liran Kotzer
3	- Entrepreneurial Vs. IntraPreneurial - process and Strategic Design	With Dr. Eyal Benjamin
4	Digital Media and Social Aspects	With Liad Agmon

5	Social Entrepreneurship	With Michal Simler
6	Case Study	
7	Entrepreneurship and Globalization, Entrepreneurship and Government	Dr. Avi Hasson (Chief Scientist)
8	- Financial aspect of entrepreneurship and funding - Project presentation and pitch	
9	- Entrepreneurs panel - success and failure in Entrepreneurship	
10	Exam	

INNOVATION - THEORY AND PRACTICE

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PREREQUESITES: Entrepreneurship 2

WAY OF TEACHING: Lectures = 3 hours/week

COURSE OBJECTIVES

What is innovation and are we using this term too often? In the course we will address innovation and its management in organizations, mostly business orientated but not only. We will review key events and cases, as well as theories and academic studies related to the sources of innovation, the enabling and stifling of innovation, and key success innovation factors. We will review the key terms used to describe innovation and analyze it, the leading schools, and the thought leaders in this domain. The students will analyze current innovations along the principle presented in the course, learn to identify innovations around them and will be prompted to suggest innovations in their work or social environment.

COURSE REQUIREMENTS

- Students will be required to study the underlying theories, as well as engage actively in thinking about innovations that they can introduce in their work space and/or their social environment. Since much of the course value will be obtained via class discussions, class attendance is important. The course assignments are structured so that it is a set of related assignments, all leading to the final presentation on the last week of the course.

- Class attendance: at least 15 out of the 22 course sessions
- Assignments:
  1. The assignments will be delivered by pairs of students.
  2. Assignments # 1-#5 weigh 15% of the grade
  3. Assignment #6 – the presentation and final paper weigh together 25%

METHODS OF LEARNING

Through reading/watching materials, lectures and class discussions, the course will expose students to existing theories about innovations, the common terms and the current practice in the industry. Students will engage in implementation of the theories and practices on innovation, in real-life situations.

METHODS AND THEORIES DISCUSSED

Innovation plays an essential role in today's business and social arena. For that reason, a good understanding of innovation process is important for everyone who wants to understand the world around them and act upon it.

This course will provide a theoretical framework as well as a collection of useful tools to promote innovations in real-life situations. The course will follow outlined structure numbered by weeks:

Week	Assignment
1. Intro: frameworks, examples	Assignment #1: choose an innovative product/service/process and analyze the innovation – what is new, how is it relevant, how is it done differently
2. The context for innovation, trends	Assignment #2: describe a trend
3. Innovation strategy, the learning strategy	
4. Creativity, structured and unstructured; Customer Journey	Assignment #3: Describe a plausible innovation domain: a deep need, an important gap, a qualified challenge, or a business/social opportunity that are big enough.
5. Innovation management – process (+agile, canvas), people	
6. Innovation management – practices, guest talk	Assignment #4: (i) How would manage the progress of your innovation? (ii) You are appointed as the head of innovation of an (choose which one) organization. What do you do?
7. Innovation types – technology and IP	
8. Innovation types – business models, social innovation, process innovation	Assignment #5: What type is you innovation?
9. Open Innovation, inside out and outside in (NIH, adoption, exploitation)	
10. Innovation and Israel – the startup nation and beyond	Assignment #6: (i) Is your innovation a typical "startup nation one"? (ii) Finalize your innovation in a presentation for a senior management or potential investors.
11. Student presentations of team innovations	

REQUIRED READING/WATCHING

- http://www.bustpatents.com/timetable.html
- http://resources.woodlands-junior.kent.sch.uk/homework/victorians/inventiotimeline.html
- Rachel Schuster: The Israel Effect http://www.haaretz.com/news/the-israel-effect-1.4560
- Ilene Prusher Innovation Center? http://www.csmonitor.com/World/Middle-East/2010/0309/Innovation- center-How-Israel-became-a-Start-Up-Nation .
- Innovation indices – the global Innovation index (TBD)
- Hargadon, A. B., & Douglas, Y. (2001). When innovations meet institutions: Edison and the design of the electric light. *Administrative Science Quarterly*,*46*(3), 476-5 http://www.cs.princeton.edu/~sjalbert/SOC/Douglas.pdf
- Furr and Dyer http://hbr.org/video/3769919760001/managing-the-uncertainty-of-innovation
- Innovation and Individual Creativity
- https://medium.com/the-rules-of-genius
- Mathematics Genius: http://nautil.us/issue/18/genius/the-twin-prime-hero-rd
- Innovation and Intellectual Property
- http://scienceprogress.org/2009/01/patent-reform-101/
- http://www.forbes.com/sites/henrychesbrough/2011/03/21/everything-you-need-to-know-about-open- innovation/
- Jill Lepore: The Disruption Machine, New Yorker, June 2014
- http://www.newyorker.com/magazine/2014/06/23/the-disruption-machine
- http://www.washingtonpost.com/opinions/five-myths-about-business-disruption/2014/06/27/57396950- fd4b-11e3-932c-0a55b81f48ce_story.html
- Robert Lambert, http://robertlambert.net/2013/02/a-fistful-of-agile-criticisms/
- Everything's amazing and nobody's happy http://www.economist.com/blogs/freeexchange/2012/09/growth
- Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds. http://www.nber.org/papers/w18315
- Response: http://www.economist.com/blogs/freeexchange/2012/09/productivity-and-growth

ADDITIONAL READING/WATCHING

- Scott Berkun (2013*) The Myths of Innovation*, http://scottberkun.com/2013/mega-summary-of-myths-of- innovation/ , http://www.stefanklocek.com/177-truths-of-innovation/

- Nathan Furr and Jeff Dyer (2014) *The Innovator's Method: Bringing the Lean Start-up into Your Organization*, Harvard Business Review Press

- Boyd, D. and Goldenberg, J. (2013) *Inside the Box: A Proven System of Creativity for Breakthrough Results* Simon & Schuster. http://www.insidetheboxinnovation.com/

- *HBR's 10 Must Reads on Innovation*

- Eric Ries (2011) *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses* Crown Business

- D. Senor and Saul Singer (2011) *Start-up Nation: The Story of Israel's Economic Miracle* Twelve. http://startupnationbook.com/

- Peter Thiel (2014) *Zero to One: Notes on Startups, or How to Build the Future* Crown Business, http://zerotoonebook.com/

Theories of innovation

Neo-Schumpeterian Economics

- Nelson, R. R., Winter, S. G., 1977. In Search for a Useful Theory of Innovation. Research Policy 6, 36-76.

- Dosi, G., 1988. The Nature of the Innovative Process, in: Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L. (Eds.), Technical Change and Economic Theory. Pinter Publishers, London and New York, pp. 221-238.

Systems of Innovation

- Freeman, C., 1982. The Economics of Industrial Innovation. MIT Press, Cambridge.

- Freeman, C., 1997. The Diversity of National Research Systems, in: Barre, R., Gibbons, M., Maddox, S. J., Martin, B., Papon, P. (Eds.), Science in Tomorrow's Europe. Economica International, Paris, pp. 5-31.

Path Dependency and Path Creation

- Arthur, W. B., 1989. Competing Technologies, Increasing Returns, and Lock-in by Historical Events. Economic Journal 99, 116-131.

- Garud, R., Karnoe, P., 2001. Path Creation as a Process of Mindful Deviation, in: Garud, R., Karnoe, P. (Eds.), Path Dependence and Creation. Lawrence Erlbaum Associates, Mahwah and

London, pp. 1-28.

Social Construction of Technology

- Pinch, T., Bijker, W. E., 1984. The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. Social Studies of Science 14, 399-341.

- Bijker, W. E., 1987. The Social Construction of Bakelite: Toward a Theory of Invention, in: Bijker, W. E., Hughes, T. P., Pinch, T. (Eds.), The Social Construction of Technological Systems - New Directions in the Sociology and History of Technology. MIT Press, Cambridge, pp. 159-187.

Large Technical Systems

- Hughes, T. P., 1987. The Evolution of Large Technological Systems, in: Bijker, W. E., Hughes, T. P., Pinch, T. (Eds.), The Social Construction of Technological Systems. MIT Press, Cambridge, pp. 51-82.

- Davies, A., 1996. Innovation in Large Technical Systems: The Case of Telecommunications, Industrial and Corporate Change 5, 1143-1180.

Technological Regimes and the Multi-level Perspective

- Geels, F. W., 2002. Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-Level Perspective and a Case-Study. Research Policy 31, 1257-1274.

- Poel, I. v. d., 2003. The Transformation of Technological Regimes. Research Policy 32, 49-68.

Technology Cycles

- Anderson, P., Tushman, M. L., 1990. Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change. Administrative Science Quarterly 35, 604-633.

- Teece, D. J., 1986. Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy. Research Policy 15, 285-305.

User Innovations and the Diffusion of Innovation

- Urban, G., von Hippel, E., 1988. Lead User Analyses for the Development of New Industrial Products. Management Science 34, 569-582.

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Course Terms

Absorptive Capacity	Agile	Brain Drain
Cathedral or Bazaar	Chasm	Christensen, Clayton
Clarke, AC	Creative Destruction	Crowdfunding
Crowdsourcing	Diffusion of Innovation	Disruptive Innovation
First Mover	Gartner's Hype Curve	Globalization

Incubator	Innovation Patent	Innovation Starvation
KPI	Kurzweill, Ray	Laggards
Lean Startup	Lock-in effects	Luddites
Makers, Maker Culture	Measuring Innovation	MVP
Network Effects	Open Innovation	Open Source
Patent Trolls	Penguin and Leviathan	Remix
Resource-based view	Reverse Innovation	"Rich vs. King"
ROI	Rogers, Everett	S shaped Curve
Schumpeter, Joseph	Scrum	Secondary Effect
Serendipity	SIT (Syst. Inv. Thinking)	Singularity
Six Sigma, Lean Six Sigma	Social Construction of Technology	Spiral Methodologies

StartUp Nation	Sustainable innovation	TBD
Tech Transfer	Technology Cycles	Toffler, Alvin
Trade Secret	Triple Package (Amy Chua)	TRIZ
Venture Capital (VC)	Waterfall Methodologies	Zero to One