Curriculum, B.Sc in Electrical and Electronics Engineering

Semester 1 (Taught in the Fall)

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.1821	Introduction to Computer Science using Python	3	2	-	2	4	-
0595.1824	Linear Algebra	6	5	2	-	7	-
0595.1826	Physics I (Mechanics)*	7	8	4	-	12	-
0595.1846	Calculus I	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 II (Electromagnetism)*	6.5	5	3	-	8	Phys. I
0595.1843	Calculus II	5	4	2	-	6	Calc. I
0595.1845	Ordinary Differential Equations	3.5	3	1	-	4	Calc. I; Linear Algebra
0595.2503	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		**20.5**	**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
0595.2507	Quantum and Solid state Physics	5	4	2	-	6	Phys. II
0595.2843	Harmonic Analysis	2.5	2	1	-	3	Calc. II; ODE; Complex Functions (in parallel)
0595.2844	Complex Functions	2.5	2	1	-	3	Linear Algebra ; Calc. II
0595.2531	Linear Circuits and Systems	5	4	2	-	6	ODE; Phys. II
0595.1000	Real life engineering with MATLAB	2.5	2	2	-	4	Linear Circuits and Systems (in parallel)
Total Semester		**21**	**17**	**9**	**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. II
0595.3532	Signals and Systems	3.5	3	1	-	4	Harmonic Analysis; Linear Circuits and Systems
Total Semester		**18**	**15**	**6**	**0**	**21**	

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 ; Linear Circuits and Systems
0595.3526	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
0595.3571	Electromagnetic Fields	3.5	3	1	-	4	Harmonic Analysis ; Phys. II; PDE
0595.3632	Random Signals and Noise	4	3	2	-	5	Prob. And Stat. ; Signals and Systems
Total Semester		**17**	**12**	**6**	**4**	**22**	

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
0595.3572	Electronics Laboratory (2)	2	-	-	4	4	Elect. Lab.1; Analog Elect. Circuits
0595.3592	Wave Transmission	3.5	3	1	-	4	Electromagnetic Fields
0595.0000	Energy Conversion	3.5	3	1	-	4	Linear Circuits and Systems; Electromagnetic Fields
0595.0000	Introduction to Digital Signal Processing	3.5	3	1	-	4	Signals and Systems
1221.8000	Entrepreneurship 1: The basics from A to Z	3	3	-	-	3	-
Total Semester		**19**	**15**	**4**	**4**	**23**	

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

Semester 7(Taught in the Fall)

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.4000	Project	3	-	-	6	6	-
0595.3593	Electronics – Laboratory (3)	2	-	-	4	4	Electronics Lab.2 ; Digital Electronic Circuits
0595.0000	Energy Conversion Laboratory	1	-	-	2	2	Energy Conversion; Elect. Lab.1
0595.0000	VLSI	3.5	3	1	-	4	DLS; Electronic Devices
0595.0000	Advanced Lab 1	1.5	-	-	3	3	-
0595.0000	Communication Systems	3.5	3	1	-	4	Random Signals and Noise
0595.1805	Introduction to Engineering Economy and Accounting	2	2	-	-	2	-
Total Semester		**16.5**	**8**	**2**	**15**	**25**	

Semester 8 (Taught in the Spring)

Number	Course	Cr.	Lec.	Rec.	Lab.	Total hours	Prerequisites
0595.4000	Project	3	-	-	2	6	-
0595.0000	RF Circuits and Antennas	3.5	3	1	-	4	Wave transmission
0595.0000	Computer Structure	3.5	3	1	-	4	Data Structure and Algorithms ; DLS
0595.0000	Advanced Lab 2	1.5	-	-	3	3	-
0595.0000	Power Electronics	3.5	3	1	-	4	Energy Conv. ; Energy Conv. Lab
1221.8000	Entrepreneurship 2: team management	3	3	-	-	3	-
1221.8000	Entrepreneurship 3: innovation management	3	3	-	-	3	-
Total Semester		**21**	**15**	**3**	**5**	**27**	
FINAL TOTAL		**152.5**	**116**	**47**	**30**	**197**	

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

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 I (Mechanics)

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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 I

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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*, 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.

Physics II (Electromagnetism)

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PREREQUESITES: Physics I

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 II

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PREREQUESITES: Calculus I

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.

Week 3-4: The chain rule, implicit differentiation. Directional derivative. Extremum. Lagrange multiplier method. Taylor's formula with Lagrange remainder.

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

Week 7-8: Triple integrals, iterated integrals. Jacobian. Cylindrical and spherical coordinates. Vector functions and parametric curves. Line integral of scalar functions.

Week 9-10: Line integral of vector functions. Work. Path independent line integrals (conservative fields). Green's theorem (in the plane). Vector fields: rotor and divergence.

Week 11-12-13: Surface area, parametric surfaces and surface integrals of scalar and vector functions. Theorems of Stokes and Gauss.

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.

Ordinary Differential Equations

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PREREQUESITES: Calculus I; 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. First order equations, the existence and uniqueness theorem.

Week 2: Second order linear equations; homogeneous equations and linear independence, the wronskian and lowering the order of an equation, homogeneous equations with constant coefficients.

Week 3: Separation to a homogeneous and an inhomogeneous problem, the method of undetermined coefficients and the method of variation of parameters.

Week 4: One sided Green's function for solving initial value problems.

Week 5: Reaction to constraints and to initial/boundary conditions.

Week 6: Generalization to nth order equations, the case of constant coefficients.

Week 7: Euler's formula, series solutions (Frobenius method), Bessel's function, Legendre's function, Hermite's function, Laguerre's function, regular and singular solutions.

Week 8: The Laplace Transform and it's applications for solving differential equations, initial and final value theorems, transforms of convolutions.

Week 9: System of first order linear equations.

Week 10: 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.

REQUIRED READING

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

Programming in 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 an introductory programming course. The course assumes no prior programming experience. The student will submit weekly programming assignments.

COURSE TOPICS

Introduction to computer structure and operating systems.

Programming in "C": variables, expressions, program flow control, functions, pointers, structures. Input/Output, constructing modular programs.

Introduction to algorithm complexity.

REQUIRED READING

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

Digital Logic Systems

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PREREQUESITES: Linear Algebra

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

COURSE TOPICS

Weeks 1-6: Introduction to discrete math (sets, Boolean functions, induction and recursion, sequences and series, directed graphs, binary representation, propositional logic, Boolean algebra, asymptotics.)

Weeks 6-7: Representation of Boolean functions by Boolean formulae.

Week 8: Combinational circuits (foundations, cost, delay, lower bounds).

Weeks 9-11: Basic combinational circuits: tress for associative functions, encoder, decder, multiplexers, shifters, adders, subtractors, representation of signed integers.

Weeks 11-12: Synchronous circuits: Foundations, timing analysis, shortest clock period.

Week 13: Finite State machines and synchronous circuits/

Week 14: Synthesis and analysis of finite state machines.

Weeks 14-16: A simple processor (instruction set architecture, ALU, datapath, file register, control, assembly)-as time permits

Week 16: Design and simulation of digital circuits using a computer.

REQUIRED READING

- Guy Even and Moti Medina: *Digital Logic Design*

ADDITIONAL READING

- R. McEliece, R.Ash, and C. Ash: *Introduction to Discrete Mathematics*, Random House
- J.E. Savage, *Model sof Computations*, Eddison Wesley
- S.A. Ward and R.H. Halstead, *Computation Structures*, MIT press
- G., A. Kandel and J.L. Mott, *Foundations of Digital Logic Design*. World Scientific

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 II

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 II; 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 II, 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.

Linear Circuits and Systems

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PREREQUESITES: ODE; Physics II

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

COURSE DESCRIPTION

Week 1: Classification of systems: linear/nonlinear, time invariant/time varying, causal/non-causal etc. Useful functions: impulse, unit step, ramp. Time-domain analysis of continuous linear time invariariant (LTI) systems. Description of the continuous LTI system by differential equations. Response to internal (initial) conditions. Response to the input excitation. Convolution. The impulse response.

Weeks 2 & 3: The (one-sided) Laplace transform (review). Solving the linear differential equations of a LTI system with the Laplace transform. Transfer functions, poles and zeros in the complex plane. Characterization of second order systems response. Stability of continuous LTI system. Feedback and its use control improve and stabilize a system.

Weeks 3 & 5: Electrical systems (review of KVL,KCL) and modeling of combinations of (translational and rotational) mechanical systems and electro-mechanical by electrical networks.

Weeks 6 & 7: State space presentation of continuous LTI systems. Some canonical presentations. Solution of the state equations in the time-domain. Solution of the state equations with Laplace transform. Transition between presentation of the system by differential equations, transfer function and canonical state space presentations. State variables feedback.

Week 7 & 8: Frequency response to sinusoidal excitation. Frequency domain analysis. By Bode frequency response plots.

Week 9: Discrete systems. Linear shift ("time") invariant (LSI) systems.. Time invariance causality in discrete systems. Discrete vs. digital. Sampled continuous LTI. Description of the LSI system by difference equations. Useful discrete functions. Solution of the difference equation in the "time-domain": Response to initial conditions. Response to excitation. Discrete impulse response. Discrete convolution.

Week 10-11: The one-sided Z transform and its properties. Its use to solve the discrete transfer function. Poles and zeros in the complex domain and stability conditions. Frequency response to sinusoidal excitation.

Week 12: State space presentation of LSI system in a state-space. Canonical presentations. Solution of the discrete state equations in the "time" domain and with the Z transform.

Week 13: Stability criteria for continuous and discrete time systems

REQUIRED READING

The students will get copy of the slides presented in class and a summary of the topics topics. The only way to have the complete material is to attend the lectures. Here is a list of recommended further reading with emphasis on texts with many solved problems. No single book matches exactly the taught material. The relevance of the list below will be evaluated in the first lecture.

- B. P. Lathi, *Linear Systems and Signals* Oxford University Press (2nd Edition) 2005.
- Di Stefano et al, *Feedback and Control Systems* (Schaum's Outline Series).
- D'Azzo, J. and C. Houpis. *Linear Control System Analysis & Design.* 4th ed., McGraw Hill, 1995
- K. Ogata, *Modern Control Engineering*, Prentice Hall (5th edition 2005)
- K. Ogata, *Discrete-time control systems*, Prentice Hall (2nd Edition 1995)

Real-Life Engineering with MATLAB

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PREREQUESITES: Linear Circuits and Systems (in parallel)

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

Week	Subject	Details	Main MATLAB Functions Introduced
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*, 2nd 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. Characteristics

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

Week 3: Sturm-Liouville problem.

Weeks 4-5: 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 6-7: 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 8-9: 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 10-11: 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 12-13: Non-homogeneous heat equations, Poisson equations in a circle and non-homogeneous wave equations.

Week 14: Free vibrations in circular membranes. Bessel equations.

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

The main goal of the course is to apply the principles of semiconductor physics in the analysis and understanding of several semiconductor-based devices: Diodes, Bipolar Junction Transistors, MOS capacitors, and MOSFETs.

COURSE TOPICS

Week 1:
-PN Junction Fabrication
-PN Junctions at equilibrium: Energy band diagrams, potential, space charge and field in the depletion region - Poisson's Equation
-Depletion Approximation
-1-Sided junctions

Week 2:
-Biasing of PN Junctions: Forward and Reverse Biased Junctions
-Carrier profiles
-Diffusion Current and Drift Current components

Week 3:
-Current in PN Junctions
-Current-voltage (I-V) characteristics: Diode equation
-Practical considerations in PN-Junctions

Week 4:
-Non-ideal diode effects: Recombination, Breakdown
-Zener Breakdown, Avalanche Breakdown
-Introduction to Optoelectronic Devices: Photodiodes, Solar cells, LEDs

Week 5:
-Optoelectronic Devices: Device Optimization
-Modeling a Diode
-Diode Capacitance - Charge Control Model

Week 6:
-Diode Capacitance - Diffusion and Junction Capacitance
-Metal-semiconductor (MS) junctions

Week 7:
- Metal-semiconductor (MS) junctions. Electrostatic description, Schottky barrier, ohmic characteristics. MS junction under bias.
-MOS Capacitors - Energy Band Diagram

Week 8:
-MOS Capacitors - Flatband, Accumulation, Depletion, Inversion, Threshold Voltage
-Voltage Drops in a MOS

Week 9:
-Small Signal Capacitance Model - C-V characteristic. Low Frequency, High Frequency measurements
-MOS field effect transistor (MOSFET). NMOS and PMOS.

Week 10:
-MOSFET Operating Principles
-MOS Analysis
-Gradual Channel Approximation

Week 11:
-MOS Current-Voltage Characteristics
-MOS Short Channel Effects

Week 12:
-Bipolar junction transistor (BJT) – electrostatic description and device design. Ideal BJT in forward active mode. Minority diffusion currents in narrow vs. wide base. BJT in various configurations, dc current and voltage gains.

Week 13: (if time permits, we will cover these additional topics)
-BJT Device Optimization
-Heterojunctions
-High electron mobility transistor (HEMT).

REQUIRED READING

- Streetman, B. *Solid State Electronic Devices*

ADDITIONAL READING

- Bar-Lev, A. *Semiconductor and Electronic Devices*
- S. M. Sze, *Physics of Semiconductor Devices*
- Kittel, C. (2005). *Introduction to solid state physics*.

Introduction to Probability and Statistics

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PREREQUESITES: Calculus II

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; Linear Circuits and Systems

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

COURSE TOPICS

Week 1-2: Discrete-time Linear Systems: classification, description using difference equations, discrete-time impulse response and convolution

Week 3-4: 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

Week 5-6: State-space representation of discrete-time LTI systems; Continuous-time Fourier Series (FS) and Discrete–time Fourier Series (DFS), convergence, Dirichlet conditions, basic properties, Parseval's theorem

Week 7-8: Continuous-time Fourier Transform (FT) and Discrete-time Fourier Transform (DTFT), basic properties, inverse transforms

Week 9-10: 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

Week 11-12: A summary of Fourier transforms and series and their relations, representing the DTFT as the Z-transform on the unit-circle

Week 13: 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; Basic signals in analog communication systems.

REQUIRED READING

- B.P. Lathi *Linear Systems and Signals*, Oxford university press 2002

ADDITIONAL READING

- A.V. Oppenheim & A.S. Willsky, *Signals and Systems* Prentice-Hall, 2nd Edition, 199 A.V.Oppenheim, R.W Schafer, and J.R. Buck, *Discrete-time signal processing*, Prentice-Hall, 2nd Edtion, 1999.

Analog Electronic Circuits

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PREREQUESITES: Electronic Devices; Linear Circuits and 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

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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: Linear Circuits and 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.

Electromagnetic Fields

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PREREQUESITES: Harmonic Analysis; Physics II; PDE

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

Random Signals and Noise

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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.

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. Design and analysis of basic electronic circuits consisting of BJT and MOSFET transistors operating as switches. Use of computer simulation program to analyze digital electronic circuits under their utmost limits.

COURSE TOPICS

Week 1: Introduction to Logic Signals and Circuits-Digital signals, logic levels, logic families, the basic inverter, the ideal and typical switch, transfer characteristics, noise margin, static and dynamic power dissipation.

Week 2: Temporal behavior: propagation delay of a gate, rise time, fall time, Delay-Power products.

Week 3: NMOS inverter-Depletion and Enhancement load, static and dynamic operation and transfer characteristics.

Week 4: NMOS logic gates. The body effect

Week 5: CMOS Inverter-Static and dynamic operation and transfer characteristics.

Week 6: Example of CMOS logic gates. Analogue transmission gate. Flip-flops-SR-FF, D-FF, JK-FF.

Week 7: Master-Slave, multi-phase circuits, shift registers and counters, synchronization and metastate.

Week 8: Dynamic Logic-Bucket Brigade and CCD analogue shift registers, dynamic shift registers, dynamic gates and dynamic decoders and PLAs.

Week 9: Memory cells-Static RAM cells, dynamic RAM cells, ROM, PROM, EPROM, E2PROM and sense amplifiers.

Week 10: Bipolar digital circuits-Characteristics of standard TTL, LSTTL, and ECL gates. Fan-in and Fan out.

Week 11: Clamping and clipping circuits. Clock Generators-Schmitt Triggers.

Week 12: Monostable and astable multivibrator circuits using CMOS, operational amplifiers and IC such as 555.

Week 13: Design of Digital Circuits-HDL and VHDL languages. Customer, ASIC, PLD's, FPGAs. Introduction to Data converters-Principle of A/D and D/A converters.

Week 14: Data Sheet-Timing diagram. Interpretation of manufacturer's data sheets.

SPECIAL REQUIREMENTS

Pspice or EWB software for course assignments and homework.

Electronics Laboratory 2

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PREREQUESITES: Electronics Laboratory 1; Analog Electronic Circuits

WAY OF TEACHING: Laboratory = 4 hours/week

COURSE TOPICS

Week 1: RC-coupled two stage amplifier

Week 2-3: Two-stage feedback amplifier

Week 4: Push-pull power amplifier

Week 5-6: Characteristics of integrated operational amplifier

Week 7-8: Inverting and non-inverting amplifiers

Week 9: Photovoltaic Energy Systems: Solar cell *i-v* characteristics, series and parallel connections, photovoltaic arrays, maximum power point tracker.

Week 10-11: Wien bridge and crystal

Week 12: The transistor as a switch

Week 13: Voltage stabilizer

LAB POLICIES

To be handed out at the start of the semester

Wave transmission

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PREREQUESITES: Electromagnetic Fields

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

COURSE TOPICS

Week 1-3: Transmission lines: Derivation of the Telegraphist's equations and their coefficients (including loss), Sinusoidal (time harmonic) solutions,

Week 5-6: Non-sinusoidal waves on lossless lines, Graphical solutions (Smith Chart).Plane

Week 7-8: Electromagnetic Waves: The wave equation, polarization, plane wave solutions, reflection of obliquely incident plane wave from layer media, Transmission line analog for the plane wave propagation and reflection, Angular spectrum of plane waves.

Week 9-10: Electromagnetic Waveguides: Modes inelectromagnetic waveguides, TE modes, TM modes, Rectangular metalic waveguides

Week 11-12: ransmission line analog for the modes' propagation and reflection

REQUIRED READING

TBA

Energy Conversion

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PREREQUESITES: Linear Circuits and 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

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

Final 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; Electronics Lab 1

WAY OF TEACHING: Laboratory = 2 hours/ week

LABORATORY MODULES

Single and three-phase transformer; DC Machine; Induction machine; Synchronous machine; Programmable controller.

LAB POLICIES

To be handed out at the start of the semester

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 TOPICS

Week 1-2: Introduction. CMOS gates, memeories, analog and mixed signal circuits, examples.

Week 3-4: MOS transistor review: models, static gates, transmission gates, tristate, BiCMOS.

Week 5-6: CAD tools: Layout (LEDIT) and circuit (SPICE).

Week 7-8: CMOS process reviewer, design rules. Prelimineary design: parameter evaluation, rise and fall time estimation, sizing, power estimation, design margining, reliability and scaling.

Week 9-10: CMOS circuit design: logic selection, timing, IO circuits, lower power design.

Week 11-12: Design strategies and options: standard cell, gate array, PLD, symbolic design, design verification, data path, examples.

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

Part A, Weeks 1-7

Baseband signals. Concepts in information theory and coding. Sampling and amplitude modulated pulses. PCM. Quantization and quantization noise. Binary line codes and their spectrum. Multileval signals. Eye diagram and synchronization. Intersymbol interference. Raise-cosine filter. Matched filter. SNR of PCM. Differential PCM. Delta modulation.

Part B, Weeks 8-14

Bandpass signals. Bandpass signal presentations. Narrow band noise. Amplitude modulations: DSB-SC, AM, SSB, Hilbert transform. Implementing amplitude modulation and detection. SNR of amplitude detection. Angle modulations. FM, NBFM, PM. Spectrum of FM and PM signals. Implementing angle modulation. SNR of FM. Preemphasis-deemphasis. Implementing frequency detection. Phase-lock loop.

REQUIRED READING

TBA

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

Computer Structure

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PREREQUESITES: Digital Logic Systems; Data Structure and Algorithms

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

COURSE TOPICS

Weeks 1-2: Technology and performance: Measuring performance, performance factors, power wall.

Weeks 3-4: Language of the computer: operations and operands, representing instructions, supporting procedures, synchronization instructions.

Weeks 5-6: Arithmetic for computers: basic operations, multiplication and division, floating point.

Weeks 7-8: Processor: datapath, control, pipe-lining, forwarding instructions, hazards, interrupts.

Weeks 9-10: Memory hierarchy: cache memory, performance, virtual memory, virtual machines, coherency.

Weeks 11-12: Storage systems: reliability, secondary storage, input/output, connecting processors memory and devices, interfaces.

Weeks 13-14: Multiprocessors: Shared memory, multithreating, multicore.

REQUIRED READING

TBA

Return to first page

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

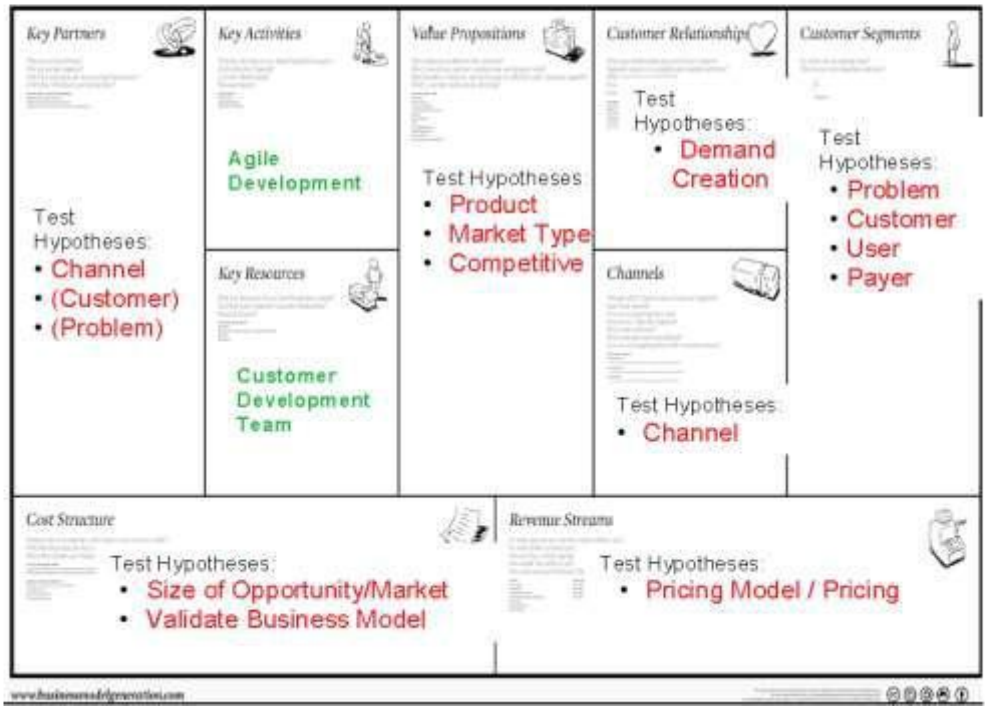
Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*. Wiley. com.
Chesbrough, H. (2007). Business model innovation: it's not just about technology anymore. *Strategy & leadership*, *35*(6), 12-17.

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*



Additional Reading Material

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	Date	Topic	Comments/Workshops
1	10.3.2015	Introduction to Entrepreneurship, type of Entrepreneurships, GEM – Global Entrepreneurship Monitor	Introductions, course description and the process
2	24.3.2015	- Marketplaces - The Business Plan and Business Model Canvas	With Liran Kotzer
3	14.4.2015	- Entrepreneurial Vs. IntraPreneurial - process and Strategic Design	With Dr. Eyal Benjamin
4	21.4.2015	Digital Media and Social Aspects	With Liad Agmon

5	28.4.2015	Social Entrepreneurship	With Michal Simler
6	5.5.2015	Case Study	
7	12.5.2015	Entrepreneurship and Globalization, Entrepreneurship and Government	Dr. Avi Hasson (Chief Scientist)
8	**15.5.2015 Friday Recanati 254**	- Financial aspect of entrepreneurship and funding - Project presentation and pitch	
9	19.5.2015	- Entrepreneurs panel - success and failure in Entrepreneurship	
10	26.5.2015	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.

- Baldwin, C., Hienerth, C., von Hippel, E., 2006. How User Innovations Become Commercial Products: A Theoretical Investigation and Case Study. Research Policy 35, 1291-1313.

Transaction Cost Theory

- Williamson, O. (1981), The economics of organization: The transaction cost approach, American Journal of Sociology, 87, 3, pp. 548-577.

Resource-Based View

- Mahoney, J.T., Pandian, J.R. (1992), The resource-based view within the conversation of strategic management, Strategic Management Journal, 13, pp. 363-380.

Dynamic Capability Theories

- Teece, D., Pisano, G. and Shuen, A. (1997), Dynamic capabilities and strategic management, Strategic Management Journal, 18, pp. 509-533.

Inter-Organizational Network theory

- Gulati, R. (1998), Alliances and networks, Strategic Management Journal, 19, pp. 293-317.

- Nooteboom, B. van Haverbeke, W., Duysters, G., Gilsing, V., van den Oord, A. (2007), Optimal cognitive distance and absorptive capacity, Research Policy, 36, pp. 1016-1034.

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