Syllabus ECE 493/Math 478

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Rubric

Complex Variables Linear Algebra, Advanced Calculus, Boundary value problems, Sturm-Liouville Theory,

ECE-493 is divided into 4 basic sections (I-IV), divided into 40 topics, delivered as 24=4*6 lectures. There will be two mid-term exams and one final. There are (in theory) 14 homework assignments, with a 15 that does not count toward your final grade (HW0 is used for evaluation in the first week). Each exam (I, II and Final) will count as 30% of your final grade, while the Assignments (HW1-14) and class participation, count for 10%.

I Complex Variables *(The frequency domain)* [Ch. 21, 23, 24]

Lect. #. Topic [Chapter.Section]

I-1 Addition, multiplication and division of complex numbers
Complex functions of a complex function (e.g., Transfer functions $H(s)$, Impedance $Z(s)$)
25. $z \in \mathbb{C}$ (e.g., complex frequency $s \equiv \sigma + i\omega$), $f(z) \in \mathbb{C}$, e^z (Phasors and delay $e^{-i\omega T}$), $\log(z)$, $\sum_n z^n$ [Ch. 21]

I-2 27. Differential calculus on $\mathbb{C}$ []
28. Cauchy-Riemann Eqs., Analytic functions, Harmonic functions [21.5] 34. Series: Maclaurin, Taylor, Laurent [24.3]

I-3 Inverses of Analytic Functions;
26. Singularities (i.e., poles, branch cuts) [24.4, 21.4.6-7, pp. 1131-4] 29. Irrotational $\nabla \times \mathbf{V} = \mathbf{0}$ [p. 826] and Incompressible $\nabla \cdot \mathbf{v} = \mathbf{0}$ [p. 839-40] fields (e.g., velocity potential $\mathbf{u} = \nabla\phi(x, y, z)$) [16.10]

I-4 30. Integral calculus on $\mathbb{C}$ []
31. $\oint z^n dz$ on the unit circle [22.3]
33. Intro to Cauchy's integral formula [23.5]
How to find $\Im Z(s)$ given $\Re Z(s)$ []

I-5 32. Cauchy's theorem []
33. Cauchy's integral formula [23.5]
35. Cauchy's Residue Theorem [24.5] []

I-6 37. Inverse Transforms: Laplace $\mathcal{L}^{-1}$ (contour integration) and Fourier $\mathcal{F}^{-1}$ []
Special pole-zero patterns: stable/causal, allpass, Minimum phase, positive real functions

I-7 Hilbert Transforms and the Cauchy Integral formula;
Review of differences between the Laplace $\mathcal{L}^{-1}$ and Fourier $\mathcal{F}^{-1}$ methods []

I-8 Brune Impedance (Positive real rational approximations (i.e., quasi-statics))
39. ODE's with initial condition (vs. Boundary value problems) []

I-9 More Inverse Laplace transformations;
Analytic continuation using power series with mirrors

I-10 38. Applications of: *Rational fraction* (e.g., $Z(s) = \frac{as^2+bs+c}{As+B}$ and *Continued fraction*

$$Z(s) = s + a/(s + b/(s + c/(s + \cdots)))$$

ladder expansions []

Exam I

II	Linear Algebra	...[Ch. 8, 10, 11, 9]
Lect.	#.Topic	[Chapter.Section]
II-1	1.Basic definitions	[8.1]
	2.Elementary operations	[8.2]
II-2	3.Solutions to $Ax = b$	[8.3, App. B, p. 1267]
	4.Matrix inverse	[8.3]
II-3	5.Matrix Algebra; Eigenvalues & vectors	[10.2, 11, 12]
	6.Transformations (change of basis)	[10.2]
II-4	7.Vector spaces $\mathbb{R}^n$	[9]
II-5	8.Optimal approximation (Least squares minimization)	[9.10, 4.4] [p. 884]
III	Advanced Calculus	[Ch. 13, 15, 16]
Lect.	#.Topic	[Chapter.Section]
III-1	9.Partial differentiation ($\frac{\partial}{\partial x}$)	[]
	10.Line surface and volume integrals	[]
III-2	11.Gradient (∇), Divergence ($\nabla\cdot$), Curl ($\nabla\times$), Laplacian (∇^2)	[]
III-3	12.Change of variables (COV) & The Jacobian (COV with volume conservation)	[]
III-4	13.Theorems: Green, Stokes, Divergence	[]
III-5	14.Potentials and conservative fields	[]
	Exam II	
IV	Boundary value (BV) problems	[Ch. 17, 18, 19]
Lect.	#.Topic	[Chapter.Section]
IV-1	15. PDE: parabolic, hyperbolic, elliptical, discriminant	
	16. PDE as a limit of system of ODEs (transmission lines)	
	17. 2^{nd} order PDE from a pair of first order ODEs	[]
IV-2	18. Separation of variables	[p. 46; 20.2-3]
IV-3	21. Special Equations of Physics: Wave, Laplace, Diffusion	[]
IV-4	22. Special functions, Fourier Series, Bessel, Legendre Polynomials, Riemann Zeta	
	20. Sturm-Liouville BV Theory	[17.7, pp. 887, 965, 1029, 1070, 1080]
IV-5	23. Fourier: Integrals, Transforms, Series, DFT	[]
IV-6	24. Laplace and z Transforms	[]
	19. The vector space $\mathbb{C}^1$	[9.6-7, 3]
	Final	

Abbreviations: WP: Wikipedia; COV: change of variables; BV: boundary value; p.: page; Ch.: chapter; ODE: ordinary differential equation; PDF: partial differential equation; MM: Mickey Mouse; DFT: Discrete Fourier Transform