Course Outline: Linear Mathematics for Imaging II, Draft #1, 8 March 2010
This course considers mathematical topics that are relevant to various aspects of imaging, including optics and digital image processing. These include vector calculus, linear differential equations, the continuous Fourier transform and its applications. Examples are drawn from imaging systems and applications. Prerequisite: 1051-320 or permission of the instructor.

This will be, both by design and of necessity, a “two-way” class. I am hopeful that the students will contribute both to the list of topics to cover and to the imaging tools available for use. In other words, I hope that we can form a “peer community of learners”.

Brief Summary of Topics:
Vector Calculus (~2 weeks) (level of Arfken Mathematical Methods for Physicists §1, or Schey
Div, Grad, Curl and all That)
- Derivatives of Vectors
  - Directional Derivative, Del Operator ∇
  - Gradient
  - Divergence
  - Curl
  - Laplacian
- Integrals of Vectors
  - Divergence Theorem
  - Stoke’s Theorem
- Applications to imaging

Differential equations and boundary-value problems (~2 weeks, level of Churchill Fourier Series & Boundary Value Problems)
- Linear differential equations
  - Linear differential equations as convolutions
  - Series solutions

Special Functions (~1 week) (320 notes §6, Fourier Methods in Imaging §7)
- exp[-x] STEP[x], chirp: exp[-πx^2]
- Dirac delta function δ[x] and its derivative

Fourier Transforms of continuous functions (~3 weeks) (Fourier Methods in Imaging §9)
- Fourier transforms of special functions
- Filtering (convolution) in the frequency domain
- Differentiation and integration as convolutions

Application of Fourier transforms (~2 weeks) (Fourier Methods in Imaging §16-19)
- Inverse filtering, Wiener filter
- Solutions of boundary-value problems via Fourier transform
  - Laplace’s equation, wave equation
  - Heat diffusion as model for image blur, solution via Fourier transform

Imaging to visualize complex analysis (if time permits)
- Complex-valued functions
- Differentiability and the Cauchy-Riemann Conditions
- Singularities and poles
- Path Integrals, rendered as images
- Cauchy Integral Formula