Course Outline:

I) Review of vector algebra fundamentals

1) definitions of vectors and scalars, vector algebra laws, unit vectors, Cartesian basis vectors
2) dot and cross product operations and interpretations, reciprocal vectors

II) Differential calculus of vector and tensor valued functions

1) vector functions of a single independent variable, particle kinematics and dynamics, Frenet formulas, particle motion in rotating coordinate systems
2) vector functions of multiple independent variables, vector and scalar fields, operations of gradient $\nabla$, divergence $\nabla^2$, and curl $(\nabla \times \nabla)$, properties of vector operations, definitions of dyads and 2nd order tensors, vector operations with 2nd order tensors, Cartesian coordinate transformations and invariance

III) Integral calculus of vector and tensor valued functions

1) line integrals of scalar and vector functions with applications the work done by a force field and the circulation of a velocity field, general path dependence of integrals, path independent integrals and scalar potentials
2) surface integrals, flux integrals, parameterization of surfaces
3) volume integrals, averaged values
4) Divergence, Stokes', Green's, and related integral theorems, orientable surfaces, simply vs. multiply connected regions, generalized forms of the Divergence and Stokes' theorems for tensors
5) application to physical balance laws (mass, momentum, energy), physical quantities and equations of motion in rotating reference frames
6) Gibbs, unit vector/dyad, and Cartesian tensor (indicial) notations

IV) Curvilinear coordinates

1) orthogonal basis vectors, reciprocal basis vectors, and scale factors
2) orthogonal coordinate systems (cylindrical, spherical, etc.), expressions for divergence, gradient, and curl of vectors and 2nd order tensors in orthogonal curvilinear coordinates
3) application to physical problems in finite elasticity: deformation gradients, Cauchy and Finger strain tensors, Cauchy and Piola-Kirchoff stress tensors, elementary invariance results for isotropic solids, torsion and flexure problems

IV) General tensor analysis
1) nonorthogonal curvilinear coordinates, standard basis vectors $\mathbf{g}$, reciprocal basis vectors $\mathbf{g}^*$, covariant and contravariant components of a vector/tensor vs. physical components
2) metric coefficients, raising and lowering of indices operations
3) differentiation of vectors and tensors, covariant differentiation, Christoffel symbols, coordinate transformation rules

Course grading policy: "weekly" HW: 45%
2 hour tests: 30%
Final Exam: 25%