VILLANOVA UNIVERSITY — Dr. A. J. PHARES
GENERAL RELATIVITY — FALL 1998

SYLLABUS

Textbooks used as refrences are, *Gravitation and Cosmology* by S. Weinberg, and *Gravitation* by Misner, Thorne & Wheeler. There will be a series of at least 12 take-home problems, equally weighted and representing 50% of the final grade. A term project and its oral presentation will count for the remaining 50% of the grade. The course outline is:

I. TENSOR CALCULUS
- I.1 VECTOR SPACES
  - Vector Space: Properties, dimensionality, base and change of base
  - Euclidean Vector Space
  - n-dimensional Geometry
- I.2 TENSOR ALGEBRA
  - Dual Vector Spaces
  - Tensor Product
  - Exterior Algebra
  - Transformations of Tensors
- I.3 DIFFERENTIAL GEOMETRY
  - Euclidean Space in Curvilinear Coordinates
  - Tensors in Differential Geometry
  - Arclengths, Volume Elements
- I.4 RIEMANN GEOMETRY
  - Christoffel Symbol and Coordinate Transformations
  - Covariant Derivatives
  - Vector Operations in n-dimensions
  - Manifolds and Geodesics
  - Riemann Tensor, Bianchi's Identity, Curvature of Space

II. SPECIAL THEORY OF RELATIVITY
- II.1 LORENTZ TRANSFORMATION
  - The 4-dimensional manifold and arclength in that manifold
  - Boost along a given axis
  - Boost along an arbitrary axis: General case of the Lorentz Transformation
  - Velocity Transformation
- II.2 RELATIVISTIC DYNAMICS
  - Relativistic Force
  - Relativistic Momentum
  - Work and Energy
- II.3 COVARIANT FORMULATION OF ELECTRODYNAMICS
  - Current density 4-vector
  - Energy-Momentum Density Tensor
  - Maxwell's Equations

III. GENERAL RELATIVITY
- III.1 PRINCIPLE OF EQUIVALENCE
  - Inertial and gravitational mass
  - Eötvös Experiment