PHYS 514 GENERAL RELATIVITY AND COSMOLOGY 2018
READING and PROBLEM SET 2

READING: Textbook, Chapter 2 (2.4 - 2.8).

PROBLEMS (due Jan 23, 2018, in class):

1. Use the Einstein Equivalence Principle to calculate the vertical distance light has fallen (equivalently the distance from the Earth's surface) after travelling 1km if it is emitted horizontally in vacuum near the Earth's surface.

2. In class, the Eötvös experiment was discussed. Summarize the analysis and determine which latitude on the earth is the best for performing the experiment. Explain your answer both in words and in equations.

3. In class I did not discuss the **Hughes-Drever** experiment. This classic experiment is a test of one of the key aspects of the Einstein Equivalence Principle (EEP), namely local Lorentz invariance. Read up on this experiment and give a discussion of how it works and why it is a test of the EEP.

4. Prove that the set of tangent vectors at a point p on a manifold $\mathcal{M}$ is a vector space.

5. Given two vector fields X and Y on M, find the local coordinate representation of the commutator $[X, Y]$.

6. To gain familiarity with the abstract definition of tangent vector, vector fields and commutator, prove the following properties (some of them stated in class):
a) The tangent vector T_p (p a point on the manifold) operates linearly on functions, i.e.

$$T_p(af + bg) = aT_p(f) + bT_p(g)$$

where a, b are real numbers and f, g are functions on the manifold.
b) The tangent vector satisfies the Leibniz rule, i.e.

$$T_p(fg) = f(p)T(g) + g(p)T(f).$$

c) The commutator satisfies the Jacobi identity stated in class.
d) If X and Y are vector fields and f and g are functions on the manifold, then fX is a vector field and

$$[fX, gY] \;=\; fg[X, Y] + (fX(g))Y - (gY(f))X.$$