

Riemannian Geometry and General Relativity, MTH G374
Professor M.Shubin
Spring 2007

Textbooks:

1. *General Theory of Relativity*, by P.A.M.Dirac. Princeton University Press, 1996.
2. *Riemannian Geometry*, by Manfredo Perdigão do Carmo. Birkhäuser, Boston, 1993.

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Riemannian geometry is designed to describe the universe of creatures that live on a curved surface or in a curved space. These little green men do not know about the world of higher dimensions, which may or may not exist. But they may discover that their world is not flat, and investigate it with the help of Riemannian geometry.

In the 1910s, Einstein discovered that Riemannian geometry can be successfully used to describe General Relativity, which is in fact a classical theory of gravitation. (Here the word “classical” is used as opposed to “quantum”, though the quantum theory of gravitation is still terra incognita!) So due to its intrinsic beauty, as well as to the wealth of applications, the Riemannian geometry lies at the core of modern mathematics.

A 69 page book by the famous physicist and a Nobel Prize winner (1933) Paul Dirac covers the core material for the course. In particular, it completely explains all prerequisites of Riemannian geometry that serve as a language of General Relativity (tensors, parallel transport, geodesics, covariant derivatives, curvature, Ricci tensor). It also covers many important aspects in physics (Einstein’s law of gravitation, the gravitational red shift, the Schwarzschild solution, black holes, etc). All of this will be covered in the course, and Dirac makes it quite easy.

The excellent textbook by do Carmo will serve to complement the book by Dirac. It describes and expands the above-mentioned aspects of Riemannian geometry, but using mathematical language. By the end of the course the students will become acquainted with application of both physical and mathematical languages in their interaction.

The course can serve as an alternative to Geometry 2 and replace Geometry 2 in all degree requirements.

The grade will be mainly based on several home assignments and possible presentations.