



# Lectures on Closed Geodesics (Grundlehren der mathematischen Wissenschaften)

*W. Klingenberg*

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The question of existence of closed geodesics on a Riemannian manifold and the properties of the corresponding periodic orbits in the geodesic flow has been the object of intensive investigations since the beginning of global differential geometry during the last century. The simplest case occurs for closed surfaces of negative curvature. Here, the fundamental group is very large and, as shown by Hadamard [Had] in 1898, every non-null homotopic closed curve can be deformed into a closed curve having minimal length in its free homotopy class. This minimal curve is, up to the parameterization, uniquely determined and represents a closed geodesic. The question of existence of a closed geodesic on a simply connected closed surface is much more difficult. As pointed out by Poincaré [Po 1] in 1905, this problem has much in common with the problem of the existence of periodic orbits in the restricted three body problem. Poincaré [l.c.] outlined a proof that on an analytic convex surface which does not differ too much from the standard sphere there always exists at least one closed geodesic of elliptic type, i. e., the corresponding periodic orbit in the geodesic flow is infinitesimally stable.

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