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Hamilton-Jacobi theory of orthogonal separation of variables is described within the framework of the invariant theory of Killing tensors, which is an analogue of the classical invariant theory of homogeneous polynomials to obtain a complete solution to the problem of orthogonal separation of variables of the Hamilton-Jacobi equation in 3D-spaces of constant curvature. The solution is based on the underlying ideas of Cartan geometry and ultimately developed into a general new algorithm that can be employed in the study of Hamiltonian systems defined by natural Hamiltonians within the framework of Hamilton-Jacobi theory. (Received August 30, 2011)