

The Index Number Problem

Construction Theorems

Atiyah–Singer index theorem

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In differential geometry, the Atiyah–Singer index theorem, proved by Michael Atiyah and Isadore Singer (1963), states that for an elliptic differential operator on a compact manifold, the analytical index (related to the dimension of the space of solutions) is equal to the topological index (defined in terms of some topological data). It includes many other theorems, such as the Chern–Gauss–Bonnet theorem and Riemann–Roch theorem, as special cases, and has applications to theoretical physics.

== History ==

The index problem for elliptic differential operators was posed by Israel Gel'fand. He noticed the homotopy invariance of the index, and asked for a formula for it by means of topological invariants. Some of the motivating examples included the Riemann–Roch theorem and its generalization the Hirzebruch–Riemann–Roch theorem, and the Hirzebruch signature theorem. Friedrich Hirzebruch and Armand Borel had proved the integrality of the $\hat{A}$ genus of a spin manifold, and Atiyah suggested that this integrality could be explained if it were the index of the Dirac operator (which was rediscovered by Atiyah and Singer in 1961).

The Atiyah–Singer theorem was announced in 1963. The proof sketched...

Halting problem

incompleteness theorems are very similar to those raised by the halting problem, and the proofs are quite similar. In fact, a weaker form of the First Incompleteness

In computability theory, the halting problem is the decision problem of, given an arbitrary computer program and an input, determining whether said program will eventually finish running and halt, or will continue to run forever. Alan Turing proved in 1937 that the halting problem is undecidable, meaning that no general algorithm exists that can correctly solve the problem for all possible program–input pairs. The problem comes up often in discussions of computability since it demonstrates that some functions are mathematically definable but not computable.

A key part of the formal statement of the problem is a mathematical definition of a computer and program, usually via a Turing machine. The proof then shows, for any program f that might determine whether programs halt, that a "pathological" program g exists for which f makes an incorrect determination. Specifically, g is the

program that, when called with some input, passes its own source and its input to f and does the opposite of what f predicts g will do. The behavior of f on g shows undecidability as it means no program f will solve the halting problem in every possible case.

== Background ==

The halting problem is a decision...

Rice's theorem

false for every program. The theorem generalizes the undecidability of the halting problem. It has far-reaching implications on the feasibility of static

In computability theory, Rice's theorem states that all non-trivial semantic properties of programs are undecidable. A semantic property is one about the program's behavior (for instance, "does the program terminate for all inputs?"), unlike a syntactic property (for instance, "does the program contain an if-then-else statement?"). A non-trivial property is one that is neither true for every program, nor false for every program.

The theorem generalizes the undecidability of the halting problem. It has far-reaching implications on the feasibility of static analysis of programs. It implies that it is impossible, for example, to implement a tool that checks whether any given program is correct, or even executes without error (it is possible to implement a tool that always overestimates or always underestimates, so in practice one has to decide what is less of a problem).

The theorem is named after Henry Gordon Rice, who proved it in his doctoral dissertation of 1951 at Syracuse University.

== Introduction ==

Rice's theorem puts a theoretical bound on which types of static analysis can be performed automatically. One can distinguish between the syntax of a program, and its semantics. The...

Schoenflies problem

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In mathematics, the Schoenflies problem or Schoenflies theorem, of geometric topology is a sharpening of the Jordan curve theorem by Arthur Schoenflies. For Jordan curves in the plane it is often referred to as the Jordan-Schoenflies theorem.

== Original formulation ==

The original formulation of the Schoenflies problem states that not only does every simple closed curve in the plane separate the plane into two regions, one (the "inside") bounded and the other (the "outside") unbounded; but also that these two regions are homeomorphic to the inside and outside of a standard circle in the plane.

An alternative statement is that if

Sylow theorems

mathematics, specifically in the field of finite group theory, the Sylow theorems are a collection of theorems named after the Norwegian mathematician Peter

Kleene's recursion theorem

recursion theorems are a pair of fundamental results about the application of computable functions to their own descriptions. The theorems were first

Edge coloring

required number of colors for the edges of a given graph is called the chromatic index of the graph. By Vizing's theorem, the number of colors needed to edge

Vector fields on spheres

mathematics, the discussion of vector fields on spheres was a classical problem of differential topology, beginning with the hairy ball theorem, and early

Wiener index

theory, the Wiener index (also Wiener number) introduced by Harry Wiener, is a topological index of a molecule, defined as the sum of the lengths of the shortest

Problem of Apollonius

Roomen solved the problem using intersecting hyperbolas, but this solution uses methods not limited to straightedge and compass constructions. François Viète

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