EDUCATION & MATHEMATICS

good will hunting math problem

Published: September 3, 2026 | Index ID: #-

Quick Takeaways

- The problems in Good Will Hunting are real mathematical challenges involving graph theory and adjacency matrices.
- The "difficult" problem involves finding homeomorphically irreducible trees with ten nodes.
- While portrayed as nearly impossible, these problems are typically encountered in senior undergraduate or graduate-level mathematics courses.
- Professor Patrick O''Donnell of the University of Toronto was the actual consultant who provided the math for the film.
- Solving these problems requires a firm grasp of algebraic graph theory and combinatorial analysis.

In the 1997 cinematic masterpiece Good Will Hunting, directed by Gus Van Sant and written by Matt Damon and Ben Affleck, the protagonist Will Hunting is a janitor at MIT who possesses a preternatural talent for mathematics. The film’s central hook involves a series of complex math problems left on a chalkboard by Professor Gerald Lambeau, meant to challenge the brightest minds in the world. But for Will, these are child''s play. For decades, fans and math enthusiasts have asked: What exactly were those problems? Were they actually unsolvable? And how can a mortal student learn to solve them?

This masterclass provides an exhaustive deep dive into the mathematical reality behind the movie. We will dissect the actual problems, explain the underlying graph theory, provide step-by-step methodologies for solving them, and explore why these specific problems were chosen to represent "genius." Whether you are a student of mathematics, a fan of the film, or an aspiring polymath, this guide serves as your authoritative resource.

Section 1: Contextualizing the Problems—The World of Gerald Lambeau

In the film, Professor Lambeau (played by Stellan Skarsgård) is a Fields Medalist—the mathematical equivalent of a Nobel Prize. He puts up a challenge on a chalkboard in the hallway of the MIT math department. He notes that it took him and his colleagues two years to prove the theorem. Will Hunting, while mopping the floors, solves it in minutes. Later, a second, even more difficult problem is posed, which Will also solves, eventually leading to the famous confrontation where he burns the solution in front of a distraught Lambeau.

The problems chosen for the film were not random scribbles. They were selected by Patrick O''Donnell, a physics professor. They belong to a branch of mathematics known as **Graph Theory**, specifically dealing with trees and adjacency matrices. While the film exaggerates the difficulty—suggesting they are unsolved mysteries of the universe—they are indeed rigorous academic exercises that require a sophisticated understanding of discrete mathematics.

The Importance of Graph Theory

Graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between objects. A graph is made up of vertices (nodes) connected by edges (lines). In the modern era, graph theory is the backbone of search engines, social networks, and logistical mapping. By using this field, the filmmakers grounded Will''s genius in a discipline that is visually representable and intellectually profound.

Section 2: Problem One—The Adjacency Matrix and Path Counting

The first problem seen in the film is presented as a multi-part challenge involving a specific graph. The prompt asks students to find several things: the adjacency matrix, the matrix representing paths of length 3, and the generating function for paths from point i to point j.

Step 1: Defining the Graph

The graph shown on the chalkboard consists of four nodes (vertices) labeled 1, 2, 3, and 4. The edges are defined as follows:

- An edge between 1 and 2.
- An edge between 2 and 3.
- An edge between 3 and 4.
- An edge between 2 and 4.

Wait, if we look closely at the film''s board, the graph is actually a directed or undirected representation where certain vertices have multiple connections or loops. For the standard academic interpretation, we treat it as an undirected graph with specific edges.

Step 2: Constructing the Adjacency Matrix (A)

The adjacency matrix A of a graph is a square matrix used to represent a finite graph. The elements of the matrix indicate whether pairs of vertices are adjacent or not in the graph.

For a graph with n vertices, the adjacency matrix is an $n \\times n$ matrix A where A_{ij} is 1 if there is an edge between vertex i and vertex j, and 0 otherwise. If there are multiple edges, the number corresponds to the count of edges.

Step 3: Calculating Paths of Length n

One of the most elegant properties of the adjacency matrix is that to find the number of paths of length n between vertices, you simply raise the matrix to the power of n. The film asks for paths of length 3. This requires calculating A^3.

Will Hunting would have performed matrix multiplication rapidly. By squaring A (A^2) and then multiplying by A again, you find the total number of ways to travel from any point to another in exactly three steps.

Section 3: Problem Two—Homeomorphically Irreducible Trees

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