

# The Four Color Theorem

<http://www.youtube.com/watch?v=xRFKoVLSzl0>

## Península a color

¡Trae los lápices de colores y colorea las comunidades autónomas peninsulares y Portugal! ¿Cuál es el número mínimo de colores que debes utilizar para que dos territorios contiguos no tengan el mismo color?



## Pre-listening

What can colors on maps show? Make a list.

.....

.....

.....

.....

.....

## Listen to and watch the video and answer questions.

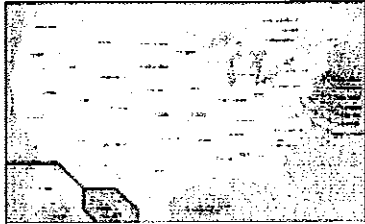
- 1) Who and when discovered the Four Color Theorem? .....
- 2) How was it proven and by whom? .....
- 3) Why did it take so long to prove the theorem? .....
- 4) What does this theorem state? .....
- 5) When is a region „adjacent“? .....
- 6) How is this theorem used? .....
- 7) How many colors do mapmakers use? .....
- 8) How can this theorem be proven? .....

# Four color theorem

From Wikipedia, the free encyclopedia



Example of a four-colored map



A four-coloring of an actual map of the states of the United States (ignoring water and other countries).

**1. First, scan the text quickly and try to supply a heading for each paragraph.**

1. ....
2. ....
3. ....
4. ....
5. ....

A. In mathematics, the **four color theorem**, or the **four color map theorem**, states that given any separation of a plane into contiguous regions, called a *map*, the regions can be colored using at most four colors so that no two adjacent regions have the same color. Two regions are called *adjacent* only if they share a border segment, not just a point.

B. Three colors are adequate for simpler maps, but an additional fourth color is required for some maps, such as a map in which one region is surrounded by an odd number of other regions that touch each other in a cycle. The five color theorem, which has a short elementary proof, states that five colors suffice to color a map and was proven in the late 19th century, however, proving four colors suffice turned out to be significantly harder. A number of false proofs and false counterexamples have appeared since the first statement of the four color theorem in 1852.

C. Despite the motivation from coloring political maps of countries, the theorem is not of particular interest to mapmakers. According to an article by the math historian Kenneth May (Wilson 2002, 2), "Maps utilizing only four colours are rare, and those that do usually require only three. Books on cartography and the history of mapmaking do not mention the four-color property."

D. The four color theorem was proven in 1976 by Kenneth Appel and Wolfgang Haken. It was the first major theorem to be proven using a computer. Appel and Haken's approach started by showing there is a particular set of 1,936 maps, each of which cannot be part of a smallest-sized counterexample to the four color theorem. Appel and Haken used a special-purpose computer program to check each of these maps had this property. Additionally, any map (regardless of whether it is a counterexample or not) must have a portion that looks like

one of these 1,936 maps. To show this required hundreds of pages of hand analysis. Appel and Haken concluded that no smallest counterexamples existed because any must contain, yet not contain, one of these 1,936 maps. This contradiction means there are no counterexamples at all and the theorem is true. Initially, their proof was not accepted by all mathematicians because the computer-assisted proof was infeasible for a human to check by hand.

E. To dispel remaining doubt about the Appel–Haken proof, a simpler proof using the same ideas and still relying on computers was published in 1997 by Robertson, Sanders, Seymour, and Thomas. Additionally in 2005, the theorem was proven by Georges Gonthier with general purpose theorem proving software.

**2. Go back to the text and read it carefully. State what these numbers refer to.**

- a) 5
- b) 1976
- c) 1,936
- d) 1852
- e) 2005
- f) 1997

**3. Now answer Qs, using the information from the text.**

- 1. What are adjacent regions?
- 2. What kinds of maps need four colors?
- 3. When was the five color theorem proven?
- 4. Is the four color theorem used by mapmakers?
- 5. How was the four color theorem proven?
- 6. Why was the proof unacceptable?
- 7. Which methods of proving the theorem were used in 2005?

**4) Which words from the text are synonyms to these expressions?**

- |                     |                           |
|---------------------|---------------------------|
| inappropriate ..... | impossible .....          |
| at first .....      | adjacent .....            |
| to be enough .....  | to put to rest .....      |
| a part .....        | to use .....              |
| on top of that..... | disproof, refutation..... |