



The Austrian Empire in 1815 stretched from Bohemia and Moravia in the north to Italy in the south, and its territory included Austria, the confederation of German states, Hungary, Bohemia, Moravia, Galicia (southern Poland), Transylvania, Silesia, Croatia, the Netherlands, and the north of Italy

Ernst Waldfried Josef Wenzel Mach

February 18, 1838 to February 19, 1916

When Ernst Mach began studying physics at the University of Vienna, he told a professor he would like to become a scientist and work in a university. The professor advised him to choose another field "because physics was finished. With few problems left to be solved, physics was simply not worth studying."*

*From *Österreichisches Biographisches Lexikon*, Vol 5, Vienna, 1972, 338-389, quoted by Alois Kernbauer, "The Scientific Community of Chemists and Physics in the Nineteenth-Century Habsburg Monarchy" in the Center for Austrian Studies Working Paper 95-4.

Mach's early years

Mach was born in Chirlitz-Turas, Moravia which was then a part of the Austrian Empire. Until the age of 14, he was schooled at home by his highly educated parents. He went on to a high school (called Gymnasium) and at the age of 17, he entered the University of Vienna. In 1860 at the age of 22, he received his doctoral degree in physics. For the next two years he taught physics and mathematics in Vienna and in 1864 he became professor of mathematics at the University of Graz.

Mach's work and discoveries

During this early period in his career as a physicist, Mach was interested in developing the psychology and physiology of sensation.

- During the 1860s he discovered the unique physiological concept which became known as Mach's bands or rings (1865) in experiments using a rotating disc. Many centuries earlier, Aristotle had attempted to explain the mystery of colored light. In the 15th century AD, Leonardo da Vinci and then Goethe in the 18th century, studied Aristotle and tried in their own ways to explain light. It was Ernst Mach's theory of bands that developed the explanation of the tendency of the human eye to see bright or dark bands between areas of sharply different light. This was important because it was an answer to the question of how to distinguish between the observer and the thing observed.
- Among his important research findings was his concept of knowledge as derived from sensation, and that observations of scientific investigation are understood in terms of experiences or sensations. This led to the position that no statement in natural science is admissible unless it can be verified by practical experience. Mach's criteria of verifiability prepared the way for Einstein's theory of relativity.
- Another important physical principle Mach proposed, which is known as Mach's principle, states that the tendency of a body at rest to remain at rest and a body in motion to continue in motion in the same direction (inertia) results from the relationship of the object with all other matter in the universe. Einstein stated that Mach's inertia theories were an inspiration for the theories of relativity.

Ernst Mach left Graz, Austria in 1867 to become professor of experimental physics at the Charles University in Prague for the next 28 years.

- In Prague he launched a new series of research activities involving the human senses of sight and hearing, from which arose the Mach number and Mach angle theories. During this period he worked on kinaesthetic sensation, the feeling associated with movement, acceleration, and change of orientation in the human body. This explains how the mind is able to sense movement and acceleration, along with the measurement of sound waves, wave propagation and supersonics (the Mach Number).



In 1886 he wrote *Analysis of the Sensations* in which he stated that knowledge is sensation and material properties can be understood only in terms of the sensations occurring by observing the entity. The book discusses Mach's famous principle of inertia, the manifestation of the interaction between a body and all the other bodies in the universe.

In 1895 Mach returned to the University of Vienna as a professor, but three years later suffered a stroke and retired from research in 1901. He continued to lecture and write until 1913. He died on February 18, 1916.

Mach's most important work was *The Science of Mechanics: A Critical and Historical Account of Its Development*. The book was very important in the study of physics for the next several decades. Albert Einstein cited the work as being the book that was critical in developing his own ideas about physics.

By the early 1900's, Mach's work was soon surpassed by one remarkable discovery after another. Mach's work laid the groundwork in physics for many of the remarkable discoveries to come.

Do you think he made the right decision by not listening to the early advice given to him?

Selected Bibliography

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Moravia became part of the Austrian Empire in 1526. The checkered eagle has been used by the Counts of Moravia since Wenzel II (1292). The original colors of the eagle, silver and red, were changed to gold and red in 1462.