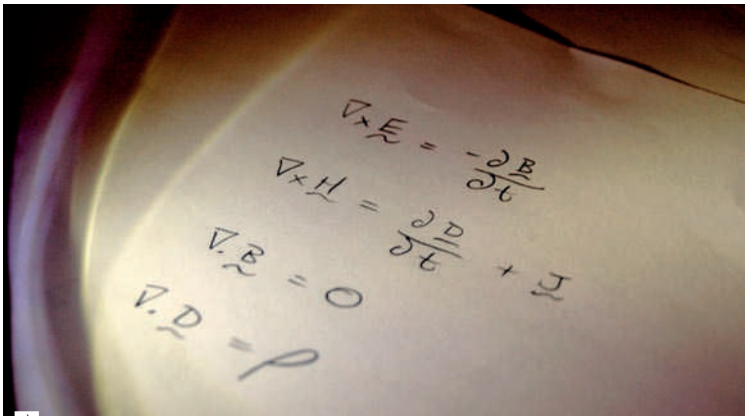

David Pile

MILESTONE 2

Classical monument

By the middle of the nineteenth century, a significant body of experimental and theoretical knowledge about electricity and magnetism had been accumulated. In 1861, James Clerk Maxwell condensed it into 20 equations. Maxwell published various reduced and simplified forms, but Oliver Heaviside is frequently credited with simplifying them into the modern set of four partial differential equations: Faraday's law, Ampère's law, Gauss' law for magnetism and Gauss' law for electricity.

One of the most important contributions made by Maxwell was actually a correction to Ampère's law. He had realized that magnetic fields can be induced by changing electric fields — an insight that was not only necessary for accuracy but also led to a conceptual breakthrough. Maxwell predicted an 'electromagnetic wave', which can self-sustain, even in a vacuum, in the absence of conventional currents. Moreover, he predicted the speed of this wave to be 310,740,000 m s^{-1} — within a few percent of the exact value of the speed of light.

"The agreement of the results seems to show that light and magnetism are affections of the same substance, and light is an electromagnetic disturbance propagated through the field according to electromagnetic laws", wrote Maxwell in 1865. The concept of light was thus unified with electricity and magnetism for the first time.

Maxwell's equations are as important today as ever. They led to the development of special relativity (MILESTONE 4) and, nowadays, almost every optics problem that can be formulated in terms of dielectric permittivity and magnetic permeability (two key constants in Maxwell's equations), ranging from optical-fibre waveguides (MILESTONE 13) to metamaterials and transformation optics (MILESTONE 21), is treated within the framework of these equations or systems of equations derived from them.

Their actual solution can, however, be challenging for all but the most basic physical geometries. Numerical methods for solving the equations were pioneered by Kane Yee and Allen Taflove, but went unnoticed for many years owing to the limited computing power available at the time. Now, however, these methods can be easily employed for solving electromagnetic problems for structures as complex as aircraft.

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