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Five Equations That Changed the World

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Union navy's reconnaissance efforts during January 1862 in the waters around the islands flanking the Savannah River to have been "dilatory," without explaining why they should be thus considered. Also, he never reveals whether the various Union efforts in the area, including the capture of Fort Pulaski, succeeded in sealing off Savannah from blockade runners. These lapses make Schiller's narrative difficult to follow.

He concludes that "the results of the rifled gun fire [on Pulaski] exceeded all expectations; revolutionized siege warfare; and made masonry forts, previously thought to be impregnable, obsolete." Focused exclusively as it is on Fort Pulaski, the author's narrative simply fails to support these assertions. Just to begin exploring whether rifles revolutionized siege warfare, a study would need a much broader scope. Such an inquiry would reveal that makers of forts and cannon had been engaged in a developmental race since before 1453, when seventy heavy Turkish bombards knocked down the walls of Constantinople. The race went on long after World War I, when the fortress of Verdun held out against rifled artillery much heavier than Gillmore's, if only because the defenders mustered firepower nearly equal to that of the attackers. During the Civil War, from the summer of 1863 until the Confederates evacuated Charleston in February 1865, Fort Sumter (another masonry fort) stood up to greater numbers of rifled cannon than Gillmore had used against Pulaski. In the broader context, then, Fort Pulaski emerges as a step, not a revolution.

Gillmore's contemporaries were less sanguine than Schiller about the advent of rifled ordnance, particularly because so many rifled guns exploded in action during the Civil War. Admiral David Dixon Porter summed up the prevailing view in the U.S. Navy at the end of the war: "Rifled cannon had not at that time made such an advance as to satisfy us that it would be the gun of the future."

All told, this book falls short of its potential.

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Guillen, Michael. *Five Equations That Changed the World.* New York: Hyperion, 1995. 277pp. $22.95

When Stephen Hawking wrote *A Brief History of Time*, his publisher said that each equation in the book would reduce sales by half. Five equations should thus reduce sales by two to the fifth power, or one thirty-second. Fortunately, Michael Guillen's publisher is not of a like mind.

Guillen, a Harvard instructor in physics and mathematics and a science editor for ABC TV, has a nice touch for the history of mathematics and physics and their impact on the world. He has taken five influential equations, each a precise expression of a foundational physical principle, and set the development of each in the intellectual context of its times and of the mind of the mathematician who devised it.

In 1680, Isaac Newton was the most celebrated natural philosopher in England. From his chair at Cambridge, he had done the differential calculus. Now his attention was drawn to the motion of the moon: why did it not fall?

By looking at the balance of forces involved, recognizing that the Earth also pulled on the Moon, and using Johannes

Kepler's century-old data on the motion of heavenly bodies, Newton was able to reason that the gravitational pull between two bodies is given by the gravitational constant times the product of the masses divided by the square of the distance between them:

$$F = G \times M \times m + d^2$$

From this basic law derives our modern ability to position satellites for naval communications and navigation.

Daniel Bernoulli was born into a family of accomplished Swiss mathematicians. After Newton identified the laws concerning the motion of solids, Bernoulli became intrigued with the behavior of moving fluids and the pressure they exert on adjacent surfaces. From the principle of the conservation of energy and by treating fluids as an assemblage of infinitely small bits, Bernoulli was able to see by 1730 that the sum of the pressure and the product of the fluid density times one-half the square of its velocity was constant:

$$P + \left(p \times \tfrac{1}{2} v^2\right) = CONSTANT$$

Thus if the velocity of the fluid is increased, the pressure it exerts on a surface must decrease. Using this concept, Otto Lilienthal and the Wright brothers designed curved surfaces that caused the fluid (air) to move faster over the top than underneath. These surfaces are called wings, and, supported by Bernoulli's law, the Blue Angels do their thing.

A century later in the 1820s, Michael Faraday entered science in an unusual way, as an unschooled but brilliant assistant at the Royal Institution. Electricity and magnetism were the central scientific questions of the day, and Faraday was soon deeply into the problems of relating them and of generating electricity. Observing that a compass needle moved slightly when brought near a current-carrying wire, Faraday extended this experiment and soon realized that electricity and magnetism were closely related and that a current could be induced in a wire by passing it through a magnetic field. Specifically, the amount of electricity induced is equal to the rate of increase (or decrease) of the magnetism as perceived by the moving wire:

$$\nabla \times E = -\partial B / \partial t$$

Faraday enjoyed a long and distinguished career with the Royal Institution. A modest and religious man, he declined the presidency of the Royal Society, and a knighthood. Plain Michael Faraday's equation is at the heart of every ship's service generator and electric motor in the Navy.

In the late nineteenth century, Rudolf Clausius, a physics professor in Germany, focused his intellectual life on heat and its behavior. If steam engines produced less work than the principle of the conservation of energy would indicate (from its potential form in coal to kinetic, in rotation), then heat flowed only from hot to cold. Why? After much difficult and abstract thinking, Clausius discovered that energy is lost in all dynamic processes; the universe gradually runs down. He produced what is known as the Second Law of Thermodynamics:

$$\Delta S_{universe} > 0$$

The inevitable decline in a ship's brightwork demonstrates this. More significantly, the law obliges heat to flow from hot to cold, thus enabling work to be extracted from the process and ships to be propelled.

Albert Einstein, whose most important work was done in the first decade of this century, produced the Theory of Special Relativity. As a young patent examiner in Switzerland, he devoted all his spare time to thinking about the relationships between mass, speed, energy, and the speed of light.

Clearly the energy of a body was related to both its mass and its speed. Yet light is a massless form of energy. By pure reasoning Einstein deduced that the absolute amount of energy in a body is the mass of that body times the square of the speed of light:

$$E = m \times c^2$$

The immediate consequence of special relativity is that speed and mass are interchangeable forms of energy. When a mass of uranium is transformed into energy, whether controlled in a nuclear reactor or uncontrolled in a bomb, special relativity is played out dramatically.

These five equations are not inventions as we think of the light bulb or the airplane, but rather they are profound expressions of the most basic principles that organize the universe. From those principles, engineers like Thomas Edison and the Wright brothers make practical applications that change our lives.

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Clift, A. Denis. *With Presidents to the Summit.* Fairfax, Va.: George Mason Univ. Press, 1993. 211pp. $23.95

This book provides an insider's recollections of a decade of presidential summit meetings. The author was the consummate staffer on the National Security Council during the Nixon and Ford administrations. Convincing evidence of Clift's professionalism came when newly elected Vice President Walter Mondale selected Clift to stay on in a Democratic administration to handle for him foreign policy, intelligence, and defense affairs. The reader is not left to wonder why Mondale decided on Clift. The author explains the pitch he made for the job, in pages 130–134.

Clift's career in staffing summits began with preparations in 1971 for the 1972 U.S.-Soviet summit and ended in mid-1980s meetings with four African heads of state. Notable activities in between were a succession of visits by foreign leaders during America's Bicentennial and the 1978 Camp David summit on the Middle East.

Clift conveys a genuine flavor of the atmosphere that surrounds summits. For example, he describes Cyrus Vance whizzing back and forth on a golf cart between the courtly Menachem Begin and the reclusive Anwar Sadat, in a Camp David version of shuttle diplomacy. At the same time, this book is about process, not substance. The author lists the agenda, but he does not provide blow-by-blow accounts of negotiations or in-depth analyses of policy outcomes. However, his attention to detail is sometimes incredible, such as the exact weight of a cannon ball or the number of chandeliers and varieties of wood in a drawing room. Although Clift's record-keeping is indeed impressive, a reader hoping for juicy gossip will be disappointed. This is no Hollywood tell-all