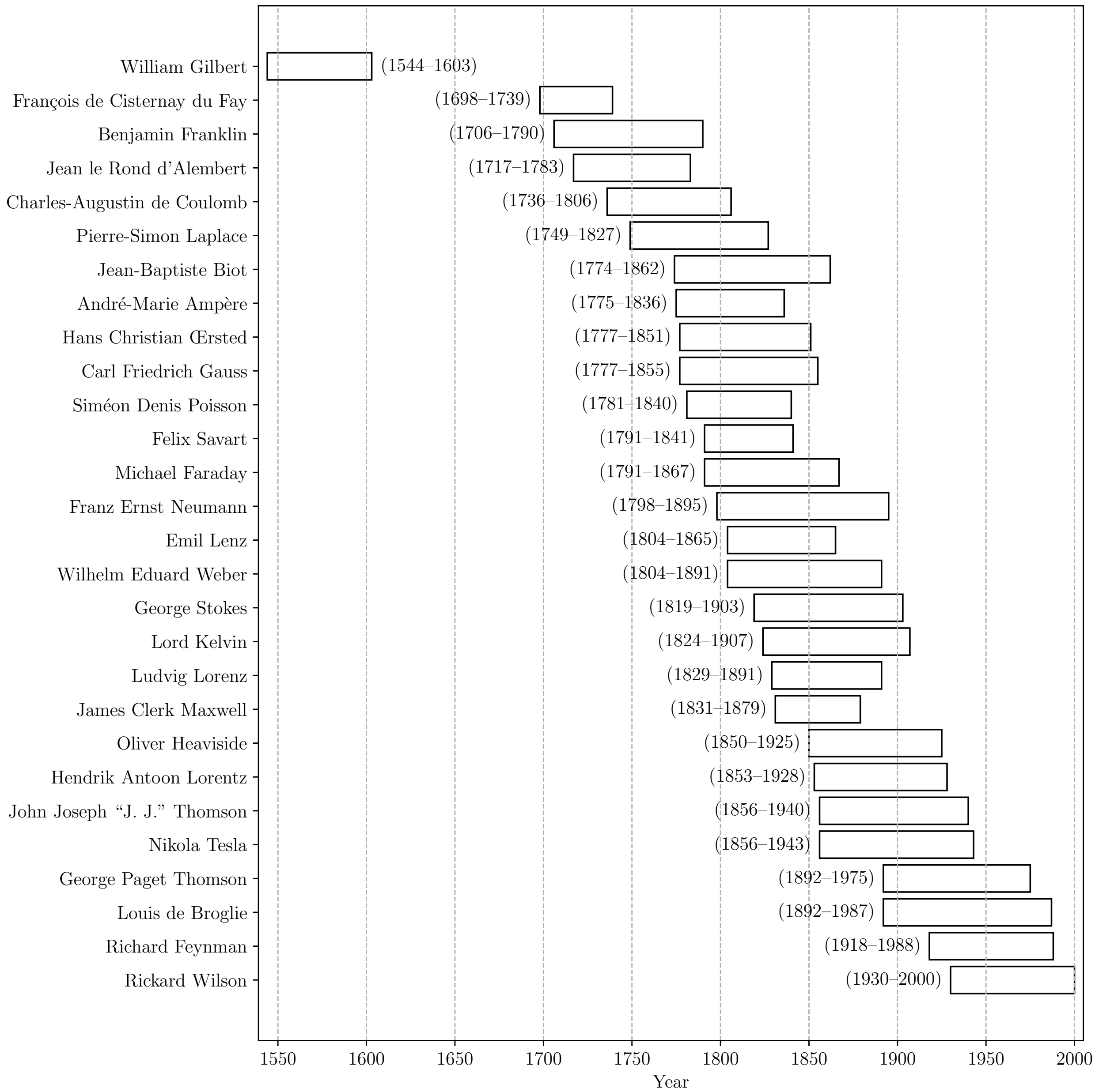
Portrait gallery in classical electromagnetism

Electromagnetism as a subject is packed with celebrities from classical physics, and it is always nice to have a face associated with the name. This portrait gallery covers the primary discoverers in electrostatics, magnetostatics, and electrodynamics.



Jean le Rond d'Alembert
(1717–1783)

French mathematician, physicist, and music theorist. In this course we use d'Alembert's method to show that waves following

$$\frac{\partial^2 E(z,t)}{\partial z^2} - \frac{1}{c^2}\frac{\partial^2 E(z,t)}{\partial t^2} = 0.$$

gives solutions of the form

$$E(z,t) = f(z - ct) + g(z + ct).$$

André-Marie Ampère
(1775–1836)

French physicist and mathematician. One of the principal founders of classical electromagnetism, which he referred to as electrodynamics. Ampère's law for static magnetic fields,

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J},$$

was later modified by Maxwell to include the displacement current.

Jean-Baptiste Biot
(1774–1862)

French physicist, astronomer, and mathematician who co-discovered the Biot–Savart law of magnetostatics with Félix Savart,

$$\mathbf{B}(\mathbf{x}) = \frac{\mu_0 I}{4\pi}\int \frac{d\mathbf{l'} \times (\mathbf{x} - \mathbf{x}')}{|\mathbf{x} - \mathbf{x}'|^3},$$

and studied the polarization of light.

Louis de Broglie
(1892–1987)

7th Duke de Broglie. French theoretical physicist and aristocrat. In his doctoral dissertation in 1924, he postulated that electrons, as well as all other matter, possess wave properties with wavelength $\lambda = h/p$, the so-called waveparticle duality. De Broglie received the 1929 Nobel Prize in Physics after his hypothesis was experimentally confirmed in 1927 by George Paget Thomson, Clinton Davisson och Lester Germer.

Charles-Augustin de Coulomb
(1736–1806)

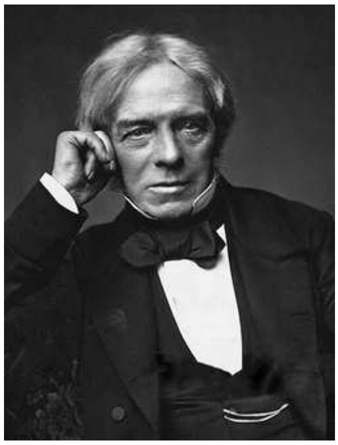
French officer, engineer, and physicist. In 1785 discovered of the law describing the electrostatic force of attraction and repulsion,

$$\mathbf{F} = \frac{qq'}{4\pi\varepsilon_0} \frac{(\mathbf{x} - \mathbf{x}')}{|\mathbf{x} - \mathbf{x}'|^3},$$

forming the basis for the concept and definition of the electric field.

Charles François de Cisternay du Fay
(1698–1739)

French chemist and superintendent of *Jardin du Roi* in Paris. Discovered that some charged items would repel while some would attract and posited the existence of two types of electricity, named "vitreous" and "resinous" (later to be known as positive and negative charge, respectively).



Michael Faraday
(1791–1867)

English chemist and physicist. Discovered the principles underlying electromagnetic induction, diamagnetism, and electrolysis. In this course, we make frequent use of Faraday's law of induction

$$\mathcal{E} = -\frac{d\Phi_{\mathrm{M}}}{dt} \quad \Leftrightarrow \quad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t},$$

which can be derived from the Lorentz force, independently of Coulombs' eller Biot–Savart's law.

Richard Feynman
(1918–1988)

American theoretical physicist. Developed the path integral formulation of quantum mechanics and the development of the theory of quantum electrodynamics. For his contributions to the development of quantum electrodynamics, Feynman in 1965 received the Nobel Prize in Physics along with Julian Schwinger and Shin'ichirō Tomonaga.

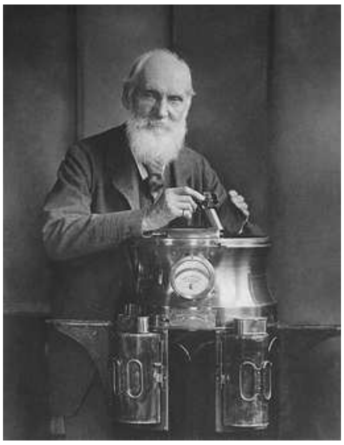
Benjamin Franklin
(1706–1790)
American polymath. One of the Founding Fathers of the United States and signer of the Declaration of Independence. Conducted experiments proposing that du Fay's "vitreous" and "resinous" electricity were not different types of "electrical fluid", but of same type, labeled as positive and negative. First to discover the principle of conservation of charge.

Carl Friedrich Gauss
(1777–1855)
German mathematician and astronomer. Director of the Göttingen Observatory in Germany and professor of astronomy. We are in this course primarily concerned with Gauss' theorem

$$\iiint (\nabla \cdot \mathbf{a})\, dV = \oint\!\!\!\!\oint \mathbf{a} \cdot d\mathbf{S}.$$

William Gilbert
(1544–1603)
English physician, physicist and natural philosopher. He is remembered today largely for his book *De Magnete* (*On Magnetism*, 1600), where electrostatic attraction was separated from magnetism. The Gilbert model of magnetic dipole moment and magnetization, with a "north" and "south" pole is named after him.

Oliver Heaviside
(1850–1925)
British mathematician and electrical engineer who invented a new technique for solving differential equations (equivalent to the Laplace transform), independently developed modern vector calculus, and rewrote Maxwell's equations in the concise and compact form as used today. Invented the coaxial cable and is the name behind the Heaviside function $H(x)$.



Lord Kelvin
(1824–1907)
William Thomson, 1st Baron Kelvin. British engineer, mathematician and physicist. Determined the value of absolute zero temperature as approximately -273.15° C. In this course we use the Kelvin–Stokes theorem,

$$\iint (\nabla \times \mathbf{a}) \cdot d\mathbf{S} = \oint \mathbf{a} \cdot d\mathbf{l},$$

after Lord Kelvin and George Stokes, being the fundamental theorem for curls.

Pierre-Simon Laplace
(1749–1827)
French polymath, a scholar whose work has been instrumental in the fields of physics, astronomy, mathematics, engineering, statistics, and philosophy. In this course we are primarily concerned with the Laplace equation

$$\nabla^2 \phi = 0$$

for the scalar electrostatic potential ϕ.

Emil Lenz
(1804–1865)
Russian physicist of Baltic German descent who is most noted for formulating Lenz's law in electrodynamics in 1834. In some sense, we can associate Lenz with the minus sign in Faraday's law of induction,

$$\mathcal{E} = -\frac{d\Phi_\mathrm{M}}{dt} \quad \Leftrightarrow \quad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}.$$

Hendrik Antoon Lorentz
(1853–1928)
Dutch theoretical physicist who in 1902 shared the Nobel Prize in Physics with Pieter Zeeman for the discovery and theoretical explanation of the Zeeman effect. Derived the Lorentz transformation of the special theory of relativity, as well as the Lorentz force

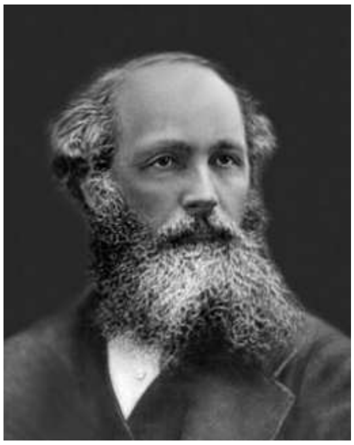
$$\mathbf{F} = q\big(\mathbf{E} + (\mathbf{v} \times \mathbf{B})\big),$$

acting upon a moving charged particle.

Ludvig Lorenz
(1829–1891)

Danish physicist and mathematician. In 1867, Lorenz gave completely general integral solutions to the differential equations of electromagnetism, including retardation due to the finite speed of light, and the introduction of the Lorenz gauge

$$\nabla \cdot \mathbf{A} + \frac{1}{c^2}\frac{\partial \phi}{\partial t} = 0.$$



James Clerk Maxwell
(1831–1879)

Scottish physicist and mathematician who was responsible for the classical theory of electromagnetic radiation, which was the first theory to describe electricity, magnetism and light as different manifestations of the same phenomenon. Maxwell's equations for electromagnetism achieved the second great unification in physics, where the first one had been realised by Isaac Newton.

Franz Ernst Neumann
(1798–1895)

German mineralogist and physicist. Devised the first formulas to calculate inductance, and the purely geometrical formula for mutual inductance is named after him. In electromagnetism, he is credited for introducing the magnetic vector potential $\mathbf{A}$, as extensively used throughout this course.

Hans Christian Œrsted
(1777–1851)

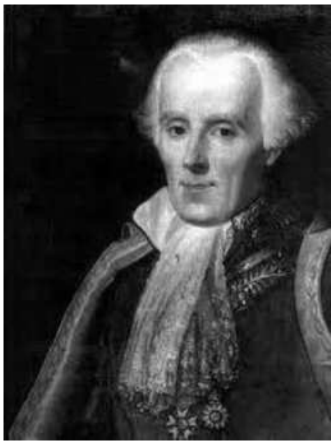
Danish chemist and physicist who discovered that electric currents create magnetic fields. The unit Oe (oersted) of the magnetic field strength $\mathbf{H}$ is named after him, and defined as $1\ \mathrm{Oe} = (4\pi)^{-1} \times 10^3\ \mathrm{A/m} \approx 79.58\ \mathrm{A/m}$.

Siméon Denis Poisson
(1781–1840)

French mathematician and physicist. Poisson predicted the *Arago spot* in his attempt to disprove the wave theory of Augustin-Jean Fresnel. In this course we are primarily concerned with the Poisson equation

$$\nabla^2\phi = \rho/\varepsilon_0$$

for the scalar electrostatic potential ϕ.



Félix Savart
(1791–1841)

French physicist and mathematician who is primarily known for the Biot–Savart law of electromagnetism,

$$\mathbf{B}(\mathbf{x}) = \frac{\mu_0 I}{4\pi}\int \frac{d\mathbf{l}' \times (\mathbf{x} - \mathbf{x}')}{|\mathbf{x} - \mathbf{x}'|^3},$$

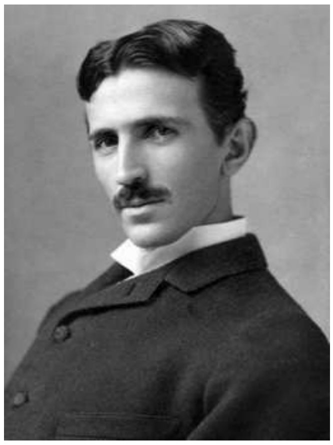
co-discovered with Jean-Baptiste Biot.

George Stokes, 1st Baronet
(1819–1903)

Irish mathematician and physicist. Formulated the Navier–Stokes equations and contributed to the theory of optical polarization (Stokes vector). We are in this course primarily concerned with Stokes' theorem

$$\iint (\nabla \times \mathbf{a}) \cdot d\mathbf{S} = \oint \mathbf{a} \cdot d\mathbf{l},$$

also denoted *Kelvin–Stokes theorem*.



Nikola Tesla
(1856–1943)

Serbian-American engineer, futurist, and inventor. Primarily known for his contributions to applied electrodynamics, such as the design of the modern alternating current (AC) electricity supply system. The unit tesla (T) of the magnetic field $\mathbf{B}$ is named after him.

Joseph John ("J. J.") Thomson
(1856–1940)
British physicist whose study of cathode rays led to his discovery of the electron. In 1897, he showed that cathode rays were composed of previously unknown negatively charged particles (now called electrons), which he calculated must have bodies much smaller than atoms and a very large charge-to-mass ratio.

George Paget Thomson
(1892–1975)
British physicist best known for experimental work on the wave nature of electrons. In 1927 he experimentally demonstrated electron diffraction, confirming Louis de Broglies hypothesis. For this, he shared the 1937 Nobel Prize in Physics. A remarkable twist is that he was the son of J. J. Thomson, *in other words, the father showed that electrons are particles, and the son showed they behave like waves!*

Wilhelm Eduard Weber
(1804–1891)
German physicist, together with C. F. Gauss inventor of the first electromagnetic telegraph. *Weber electrodynamics* was a theory of electromagnetism that preceded Maxwell electrodynamics, and was replaced by it by the end of the 19th century. In the formulation of Weber electrodynamics, Coulomb's law becomes velocity and acceleration dependent; hence the Weber electrodynamics was only applicable to quasi-static electromagnetic fields.

Rickard Wilson
(1930–2000)
Swedish scientist and architect. Discoverer of the fatilar calculus, presented in 1955.