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## Appendix C

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### *Historical notes*

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We provide brief historical notes on some of the prominent mathematicians, scientists and engineers who have made significant contributions to the ideas that are described in this text. In some cases this contribution is a general mathematical technique, and in others it is a development in fluid mechanics or a specific idea in the theory of water waves. The selection that has been made is, of course, altogether the responsibility of the author, and it includes only those researchers who died at least 20 years ago.

**Airy, Sir George Biddell (1801–92)** British mathematician and physicist, who was Astronomer Royal for 46 years; he made contributions to theories of light and, of course, to astronomy, but also to gravitation, magnetism and sound, as well as to wave propagation in general and to the theory of tides in particular.

**Bernoulli, Daniel (1700–82)** Dutch-born member of the famous Swiss family of about 10 mathematicians (fathers, sons, uncles, nephews), best known for his work on fluid flow and the kinetic theory of gases; his equation for fluid flow first appeared in 1738; he also worked in astronomy and magnetism, and was the first to solve the Riccati equation.

**Bessel, Friedrich Wilhelm (1784–1846)** German mathematician who was, for many years, the director of the astronomical observatory in Königsberg; he was the first to study the equation that bears his name (which arose in some work on the motion of planets); he carried out a lengthy correspondence with Gauss on many mathematical topics.

**Boussinesq, Joseph (1842–1942)** French mathematician and scientist who wrote an analytical treatment of various aspects of water (and fluid) flows.

**Cauchy, Baron Augustin Louis (1789–1857)** French mathematician who did important work in astronomy and mechanics, but is remembered

mainly as one of the founders of the modern theory of functions of a complex variable; he developed the first comprehensive theory of complex numbers and introduced a number of fundamental theorems in complex analysis which have proved very significant in both pure and applied mathematics.

**D'Alembert, Jean le Rond (1717–83)** French mathematician and physicist who discovered many fundamental theorems in general dynamics, and also in celestial mechanics; in addition, he made important contributions to the theory of partial differential equations.

**Descartes, René du Perron (1596–1650)** French philosopher and mathematician whose aim was to reduce all the physical sciences to purely mathematical principles, and in particular in terms of geometric interpretations; he is credited with the invention of analytical geometry. (His followers called themselves 'Cartesians'.)

**Euler, Leonhard (1707–83)** Quite outstanding Swiss mathematician who made very significant and fundamental contributions to all branches of mathematics and its applications: differential equations, infinite series, complex analysis, mechanics and hydrodynamics, and the calculus of variations; he was very influential in promoting the use and understanding of analysis.

**Fermat, Pierre de (1601–75)** French mathematician who regarded mathematics as a hobby (he was a lawyer by training); he made very important contributions to analytical geometry, the calculus, probability theory and, of course, to the theory of numbers (his famous Last Theorem); he investigated optics mathematically and, among other successes, formulated his Principle.

**Fredholm, Erik Ivar (1866–1927)** Swedish mathematician who founded the modern theory of integral equations, which was developed from his interests in differential equations and mechanics.

**Froude, William (1810–79)** English engineer and naval architect who founded the modern science of predicting forces on ships from experiments on small-scale models; he built the first ship-model tank at his home in Torquay.

**Gauss, Karl Friedrich (1777–1855)** German mathematician – one of the foremost of all mathematicians (often rated as the equal of the other two pre-eminent mathematicians and scientists: Archimedes and Newton); he had already made a number of important discoveries by the age of 17; his interests ranged over algebra, real and complex analysis, differential equations and differential geometry, as well as number theory (which remained an enduring interest throughout his

life); he used his mathematical skills in the study of astronomy, electromagnetism, and theoretical mechanics.

**Green, George (1793–1841)** English mathematician who was self-taught (which often meant that he used unconventional methods); he made significant advances in mathematical physics (and is generally credited with laying the foundations for these studies at Cambridge University); he introduced the potential function – in particular in applications to electricity and magnetism – and his famous theorem relating single/double integrals to double/triple integrals; he also made contributions to the theory of waves, to elasticity and to theories of light.

**Hamilton, Sir William Rowan (1805–65)** Irish mathematician who introduced the quaternion to the mathematical community, and showed how commutativity had to be set aside in some branches of mathematics; he tackled many problems in physics and mechanics – indeed, he coined the word ‘vector’; his work on mechanics that led to his ‘Hamiltonian function’ was started in his doctoral thesis.

**Hankel, Hermann (1839–73)** German mathematician who made contributions to complex and hypercomplex numbers, to the theory of quaternions and to the theory of functions; he was the first to suggest the concept of ‘measure’.

**Heaviside, Oliver (1850–1925)** English electrical engineer who developed the operational calculus, which he applied to the equations that arise in engineering problems.

**Helmholtz, Herman Ludwig Ferdinand von (1821–94)** German mathematician who was the first to study the equation that is most closely associated with his name (which he encountered in a problem on the oscillation of air in a tube with an open end); he also made contributions to the classification of geometries and to the axioms of arithmetic.

**Hugoniot, Pierre Henri (1851–87)** French scientist whose main interests were centred on ballistics; he solved various problems in gas dynamics and found the conditions that must exist across a shock wave.

**Jacobi, Karl Gustav Jacob (1804–51)** German mathematician and mathematical physicist who did important work on elliptic functions (where, to some extent, he was competing with Abel), analysis, number theory, geometry and mechanics; he introduced a functional determinant (the Jacobian) and developed links between elliptic functions and number theory, methods of integration, and differential equations.

**Kelvin, Lord (Sir William Thomson) (1824–1907)** Irish physicist who discovered the Second Law of Thermodynamics; the study of thermodynamics was his most important work, but he also made significant contributions to the theory of telegraphy (and almost every other branch of science).

**Kronecker, Leopold (1823–91)** German mathematician who, though gifted, never excelled in any one specific area; he worked on number theory, algebra and elliptic functions; in linear algebra he introduced his delta symbol.

**Lagrange, Joseph Louis (Comte) (1736–1813)** Italian-born French mathematician who revolutionised the study of mechanics; he was recognised as having outstanding ability by the age of 16, and held a professorial chair by 19; he gave the first general solution of a problem at the heart of the calculus of variations and introduced analytical principles in the study of mechanics and fluid mechanics.

**Laguerre, Edmond (1834–86)** French mathematician who did significant work on both projective and Euclidean geometries; he made contributions to analysis, including integration theory and the summation of series.

**Lamb, Sir Horace (1849–1934)** British mathematician, generally regarded as the outstanding applied mathematician of his time; he made important contributions to the theories of hydrodynamics and sound, as well as to elasticity and mechanics (and produced one of the seminal papers in the early days of the science of seismology); he is remembered as an exceptional teacher and a first-rate author of text books, most notably his treatise on fluid mechanics: *Hydrodynamics*.

**Laplace, Marquis Pierre Simon de (1749–1827)** French mathematical physicist who made contributions to the study of celestial mechanics and, in particular, explained the orbits of Jupiter and Saturn; he developed ideas in the use of the potential function and orthogonal functions, and introduced his integral transform; he was also an important player in the development of the theory of probability.

**Mach, Ernst (1838–1916)** Austrian physicist and philosopher who had a considerable influence on 20th century scientific thought; he was a positivist who provided the basis for the Logical Positivist movement.

**Navier, Claude Louis Marie Henri (1785–1836)** French mathematician who did much work on mechanics; in particular he was the first to derive the equations that describe a viscous fluid (which appeared in 1821), although others later and independently obtained the same

results; this work was based on experimental evidence coupled with Newton's ideas on friction.

**Newton, Sir Isaac (1642–1727)** English natural philosopher and mathematician, who was the pre-eminent scientist of the Age of Reason; he developed many fundamental ideas in mathematics – not least his version of the calculus – and in optics and, above all, in his discovery of the Law of Gravitation; in his *Principia Mathematica*, although he described all the concepts in primarily geometrical terms, he laid the foundations for our modern mathematical approach to all branches of mechanics.

**Poincaré, Jules Henri (1854–1912)** French mathematician and mathematical physicist who worked mainly in the area of celestial mechanics, but who also made contributions to the theory of dynamics more generally and to the theory of automorphic functions; he developed techniques now familiar in the use of asymptotic expansions and in probability theory; he also made important discoveries on the dynamics of the electron, and even produced results that pre-dated Einstein's Theory of Relativity.

**Rankine, William John Macquorn (1820–72)** Scottish engineer and physicist who trained originally as a civil engineer; he is regarded as one of the founders of the science of thermodynamics: the Rankine cycle is familiar to the student of heat engines; his work also included a physical and mathematical theory of shock waves.

**Rayleigh, Lord (John William Strutt) (1842–1919)** English physicist who received the Nobel prize for physics in 1904; he made contributions to virtually every branch of physics and mathematical physics, including the theory of sound, optics, electrodynamics, hydrodynamics (especially capillarity and viscosity) and elasticity.

**Reynolds, Osborne (1842–1912)** British engineer and physicist best known for his work on hydraulics and hydrodynamics; he formulated the theory of lubrication and did some classical work on the resistance of flow through parallel channels; he also investigated the transition from laminar to turbulent flow.

**Riemann, Georg Friedrich Bernhard (1826–66)** German mathematician who did fundamental and innovative work on geometry; his ideas in non-Euclidean geometry and topology led to significant advances in pure mathematics, and he also made important contributions to complex algebraic function theory; he extended Cauchy's work on complex functions, basing new developments on geometrical ideas, leading to the concept of Riemann surfaces; many aspects of his work found

applications, after his death, in physics – especially in relativity; Riemann's life was short and, in terms of publications, he was not prolific, but he had a profound effect on many branches of mathematics and mathematical physics.

**Russell, John Scott (1808–82)** Scottish engineer, scientist and naval architect who was commissioned in 1834 to investigate the possibility of rapid steamboat travel on canals; this led to his extensive interest in and study of water waves, and to the design of fast ships; he founded the Institute of Naval Architects and played an important role in the design of the *Great Eastern* (with Brunel) and of HMS *Warrior*.

**Schrödinger, Erwin (1887–1961)** Austrian theoretical physicist who, with Dirac, was awarded the 1933 Nobel prize for physics for the outstanding work on wave mechanics and its applications to atomic structure.

**Stokes, Sir George Gabriel (1819–1903)** Irish mathematician and physicist whose most important work was concerned with wave propagation – in fluids, elastic solids and of light and sound; he also made important contributions to the theory of polarised light and to X-rays.

**Taylor, Sir Geoffrey Ingram (1886–1975)** English mathematician, physicist and engineer who made significant contributions to fluid mechanics (particularly theories of the atmosphere), material science and to chemical and nuclear physics (mainly in the area of explosives); he was gifted at seeing general physical principles in all manner of everyday happenings, and in devising ingenious experiments.

**Weber, Wilhelm Eduard (1804–91)** German physicist who made significant contributions to the theory of absolute electrical measurement and units; he wrote a treatise on waves with his brother Ernst Heinrich Weber (1795–1878), who was himself an outstanding anatomist and physiologist (who also made some contributions to concepts in psychology).