ELEMENTS OF DIFFERENTIAL CALCULUS pdf

1: Elements of the Differential and Integral Calculus

Elements of the Differential and Integral Calculus By a New Method, Founded on the True System of Sir Isaac Newton, Without the Use of Infinitesimals or Limits by Catherinus Putnam Buckingham Harmonic Functions by William Elwood Byerly.

The Elements of Calculus Calculus is the foundation of the modern mathematics of physics and engineering Calculus was invented by Newton and Leibnitz at the end of the 17th century. While algebra had been an important addition to mathematics in the immediately preceding centuries, it provided mainly a notational convenience. A very significant convenience, to be sure, but it did not provide much additional power to mathematical investigations. Calculus, however, changed mathematics radically, and possessed great power and range, in practical matters as well as theoretical. Calculus involves a convenient representation of certain limiting processes, which were hinted at in earlier mathematics, but were very difficult to use, and then only in particular problems. In the educational curriculum for science and engineering, calculus forms a bridge between elementary mathematics, such as geometry, algebra and trigonometry, and advanced mathematics, such as differential equations, vector analysis and complex variables. In this position, it has other duties to perform other than simply introducing its elements. To begin the study of calculus, concepts of function, continuous function and limits are necessary, as well as some idea of the nature of mathematical proof. During the course, the student also should be introduced to the theory of curves, infinite series, power series, elementary functions, convergence, Fourier series, and other topics, as examples to which calculus can be applied. Finally, the course should foster manipulative skills, and even introduce numerical methods, such as differencing and quadrature. In all this, the central idea of calculus tends to be obscured. The essence of calculus are the definitions of the derivative and integral as limit processes. Aside from the details, that is all there is to calculus. The use of these concepts is called analysis. It used to be the custom to divide the Calculus course into a term of Differential Calculus followed by a term of Integral Calculus. This tenacious error appealed to the orderly paedagogue who viewed calculus as a set of rules, but was not efficient in presenting the subject to the reasoning mind. Richard Courant perceived this clearly, and promoted a unified development based on the reciprocal relations between differential and integral calculus. Although I did not encounter his book until later, it still appears to be the best calculus text ever likely to be written. The selection of topics, and the methods of treatment, are excellent. Among other things, it has good exercises with answers and hints. The somewhat hidden limiting process makes a rigorous mathematician nervous, but the power in applications is great. In this case, we simply differentiate f and g iteratively until the form is defined. While studying differential calculus, one can also go into the matter of finite differences and their uses. The integral calculus makes great use of the Fundamental Theorem, mentioned above, and shows that for every property of the derivative, there is a corresponding property of the integral. For example, the Chain Rule becomes integration by parts: In particular, the table of derivatives can also be interpreted as a table of integrals. There is great fun in finding the integrals of elementary functions. Of course, it is the mirror image of the Mean Value theorem for the derivative. Since many problems can be analyzed using elementary functions, integral calculus is quite powerful in applications such as the determination of areas, volumes, centroids, moments of inertia, as well as in the solution of problems of motion. A very convenient tool is a handbook of integrals. The mental and algebraic agility acquired by "doing integrals" can be obtained in no other way. If the student is going no farther in analysis, the calculus course should end with a short treatment of the most useful differential equations e. Integration also creates new functions that can be studied, such as the gamma function, and elliptic integrals. Another important concept introduced in calculus courses is the Taylor series, where the derivatives of a function at a point determine its behavior in the neighborhood. The properties of infinite series, such as convergence and uniform convergence, are conveniently introduced at the same time, concentrating on power series. These concepts are useful for further progress in understanding mathematics. The first course in calculus leads on to many extensions and applications, both theoretical and practical. The extension to three dimensions is aided by vector concepts, and the results can be applied to differential geometry. Limits and infinte series deserve further attention, and are applied to improper integrals, those with infinite limits. These topics in differential and integral calculus may form a course in Advanced Calculus, such as is presented by the second volume of Courant, or the excellent text by Widder. The first course in calculus can be begun as soon as sufficent algebraic skills have been learned, best accomplished by good courses in algebra and trigonometry, and mathematical curiosity has been excited. Calculus should immediately follow a good course in algebra and analytic geometry for best results. A course in differential equations can immediately follow calculus for students of physics and engineering, since it is applied early in these curricula. An Advanced Calculus course requires mathematical maturity in addition to manipulative skills. Physics students may well have been introduced to many of its topics earlier in their studies. For example, electromagnetism involves vectors, surface integrals and partial derivatives. Thermodynamics makes use of partial derivatives and concepts from differential geometry. Mechanics involves simple differential equations. All these subjects call upon the mathematical maturity developed in Calculus. Advanced calculus is a good place to tie all these things together, one final survey of the field, and a proper goal for the undergraduate. A good algebra course is essential for success in calculus. Like calculus courses, algebra courses are mainly applications, the fundamentals blending into the background. Unfortunately, most courses are very poor because of the lure of presenting them as a system of rules and the lack of competent instructors. Manipulation is important, but understanding is golden. Preparation in algebra should include complex numbers, introduced as roots of algebraic equations, and simple vectors. These concepts should continually be exercised at all levels, and can be applied, for example, to alternating-current circuits as well as to optics and other areas where phase is important. The combination of complex numbers and analysis must wait until postgraduate work. Calculus is essential preparation for this. In any case, much the same ground must be covered in iterative passes, going deeper each time. This is the only way a good understanding of anything worthwhile can be acquired. Courant, Differential and Integral Calculus, 2nd ed. Blackie, , 2 vols. The first volume contains the introductory course in calculus, with optional advanced topics. I understand that this book is now out of print, which is a great shame. The alternatives are not nearly as convenient and useful. Widder, Advanced Calculus, 2nd ed. Dover, 1st ed. Calvert Created 4 March

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Excerpt. Increments and their Limiting Ratio Differential Defined; Differential Coefficient General Method of Differentiation. Differential Of any Power of a Variable Differential of the Sum or Difference of Several Functions Differential of the Product of Several Functions Differential Of' a Fraction.

History of calculus Modern calculus was developed in 17th-century Europe by Isaac Newton and Gottfried Wilhelm Leibniz independently of each other, first publishing around the same time but elements of it appeared in ancient Greece, then in China and the Middle East, and still later again in medieval Europe and in India. Ancient[edit] Archimedes used the method of exhaustion to calculate the area under a parabola. The ancient period introduced some of the ideas that led to integral calculus, but does not seem to have developed these ideas in a rigorous and systematic way. Calculations of volume and area , one goal of integral calculus, can be found in the Egyptian Moscow papyrus 13th dynasty , c. He used the results to carry out what would now be called an integration of this function, where the formulae for the sums of integral squares and fourth powers allowed him to calculate the volume of a paraboloid. Madhava of Sangamagrama and the Kerala School of Astronomy and Mathematics thereby stated components of calculus. A complete theory encompassing these components is now well known in the Western world as the Taylor series or infinite series approximations. I think it defines more unequivocally than anything else the inception of modern mathematics, and the system of mathematical analysis, which is its logical development, still constitutes the greatest technical advance in exact thinking. Pierre de Fermat , claiming that he borrowed from Diophantus , introduced the concept of adequality , which represented equality up to an infinitesimal error term. Isaac Newton developed the use of calculus in his laws of motion and gravitation. The product rule and chain rule , [15] the notions of higher derivatives and Taylor series , [16] and of analytic functions [citation needed] were introduced by Isaac Newton in an idiosyncratic notation which he used to solve problems of mathematical physics. In his works, Newton rephrased his ideas to suit the mathematical idiom of the time, replacing calculations with infinitesimals by equivalent geometrical arguments which were considered beyond reproach. He used the methods of calculus to solve the problem of planetary motion, the shape of the surface of a rotating fluid, the oblateness of the earth, the motion of a weight sliding on a cycloid , and many other problems discussed in his Principia Mathematica In other work, he developed series expansions for functions, including fractional and irrational powers, and it was clear that he understood the principles of the Taylor series. He did not publish all these discoveries, and at this time infinitesimal methods were still considered disreputable. Gottfried Wilhelm Leibniz was the first to state clearly the rules of calculus. These ideas were arranged into a true calculus of infinitesimals by Gottfried Wilhelm Leibniz , who was originally accused of plagiarism by Newton. His contribution was to provide a clear set of rules for working with infinitesimal quantities, allowing the computation of second and higher derivatives, and providing the product rule and chain rule , in their differential and integral forms. Unlike Newton, Leibniz paid a lot of attention to the formalism, often spending days determining appropriate symbols for concepts. Today, Leibniz and Newton are usually both given credit for independently inventing and developing calculus. Newton was the first to apply calculus to general physics and Leibniz developed much of the notation used in calculus today. The basic insights that both Newton and Leibniz provided were the laws of differentiation and integration, second and higher derivatives, and the notion of an approximating polynomial series. When Newton and Leibniz first published their results, there was great controversy over which mathematician and therefore which country deserved credit. Newton derived his results first later to be published in his Method of Fluxions , but Leibniz published his " Nova Methodus pro Maximis et Minimis " first. Newton claimed Leibniz stole ideas from his unpublished notes, which Newton had shared with a few members of the Royal Society. This controversy divided English-speaking mathematicians from continental European mathematicians for many years, to the detriment of English mathematics. It is Leibniz, however, who gave the new discipline its name. Newton called his calculus " the science of fluxions ". Since the time of Leibniz and Newton, many mathematicians have contributed to the continuing development of calculus. One of the first and most complete works on both infinitesimal and integral calculus was written in by Maria Gaetana Agnesi. In early calculus the use of infinitesimal quantities was thought unrigorous, and was fiercely criticized by a number of authors, most notably Michel Rolle and Bishop Berkeley. Berkeley famously described infinitesimals as the ghosts of departed quantities in his book The Analyst in Working out a rigorous foundation for calculus occupied mathematicians for much of the century following Newton and Leibniz, and is still to some extent an active area of research today. Several mathematicians, including Maclaurin , tried to prove the soundness of using infinitesimals, but it would not be until years later when, due to the work of Cauchy and Weierstrass , a way was finally found to avoid mere "notions" of infinitely small quantities. Following the work of Weierstrass, it eventually became common to base calculus on limits instead of infinitesimal quantities, though the subject is still occasionally called "infinitesimal calculus". Bernhard Riemann used these ideas to give a precise definition of the integral. It was also during this period that the ideas of calculus were generalized to Euclidean space and the complex plane. In modern mathematics, the foundations of calculus are included in the field of real analysis , which contains full definitions and proofs of the theorems of calculus. The reach of calculus has also been greatly extended. Henri Lebesgue invented measure theory and used it to define integrals of all but the most pathological functions. Laurent Schwartz introduced distributions , which can be used to take the derivative of any function whatsoever. Limits are not the only rigorous approach to the foundation of calculus. The resulting numbers are called hyperreal numbers , and they can be used to give a Leibniz-like development of the usual rules of calculus. There is also smooth infinitesimal analysis , which differs from non-standard analysis in that it mandates neglecting higher power infinitesimals during derivations. Significance[edit] While many of the ideas of calculus had been developed earlier in Greece , China , India , Iraq, Persia , and Japan , the use of calculus began in Europe, during the 17th century, when Isaac Newton and Gottfried Wilhelm Leibniz built on the work of earlier mathematicians to introduce its basic principles. The development of calculus was built on earlier concepts of instantaneous motion and area underneath curves. Applications of differential calculus include computations involving velocity and acceleration , the slope of a curve, and optimization. Applications of integral calculus include computations involving area, volume , arc length , center of mass , work , and pressure. More advanced applications include power series and Fourier series. Calculus is also used to gain a more precise understanding of the nature of space, time, and motion. For centuries, mathematicians and philosophers wrestled with paradoxes involving division by zero or sums of infinitely many numbers. These questions arise in the study of motion and area. The ancient Greek philosopher Zeno of Elea gave several famous examples of such paradoxes. Calculus provides tools, especially the limit and the infinite series , that resolve the paradoxes.

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6: Differential (infinitesimal) - Wikipedia

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