SPECIAL FUNCTIONS MATHEMATICAL PHYSICS pdf

1: Special functions - Wikipedia

of mathematical physics with emphasis on those techniques that would be most useful in preparing a student to enter a program of graduate studies in the sciences or the engineering discip-.

See Article History Special function, any of a class of mathematical functions that arise in the solution of various classical problems of physics. These problems generally involve the flow of electromagnetic, acoustic, or thermal energy. Different scientists might not completely agree on which functions are to be included among the special functions, although there would certainly be very substantial overlap. At first glance, the physical problems mentioned above seem to be very limited in scope. From a mathematical point of view, however, different representations have to be sought, depending on the configuration of the physical system for which these problems are to be solved. For example, in studying propagation of heat in a metallic bar, one could consider a bar with a rectangular cross section , a round cross section, an elliptical cross section, or even more-complicated cross sections; the bar might be straight or curved. Every one of these situations, while dealing with the same type of physical problem, leads to somewhat different mathematical equations. The equations to be solved are partial differential equations. To apprehend how these equations come about, one can consider a straight rod along which there is a uniform flow of heat. Let u x, t denote the temperature of the rod at time t and location x, and let q x, t denote the rate of heat flow. This means that the rate at which heat is accumulating at a point is proportional to the rate at which the temperature is increasing. The latter is a mathematical way of asserting that the steeper the temperature gradient the rate of change of temperature per unit length , the higher the rate of heat flow. Partial differential equations are harder to solve than ordinary differential equations, but the partial differential equations associated with wave propagation and heat flow can be reduced to a system of ordinary differential equations through a process known as separation of variables. These ordinary differential equations depend on the choice of coordinate system , which in turn is influenced by the physical configuration of the problem. The solutions of these ordinary differential equations form the majority of the special functions of mathematical physics. Among the many other special functions that satisfy second-order differential equations are the spherical harmonics of which the Legendre polynomials are a special case , the Tchebychev polynomials, the Hermite polynomials, the Jacobi polynomials, the Laguerre polynomials, the Whittaker functions, and the parabolic cylinder functions. As with the Bessel functions, one can study their infinite series , recursion formulas, generating functions, asymptotic series, integral representations, and other properties. Attempts have been made to unify this rich topic, but not one has been completely successful. In spite of the many similarities among these functions, each has some unique properties that must be studied separately. Some of the special functions can be expressed in terms of the hypergeometric function. While it is true, both historically and practically, that the special functions and their applications arise primarily in mathematical physics, they do have many other uses in both pure and applied mathematics. Bessel functions are useful in solving certain types of random-walk problems. They also find application in the theory of numbers. The hypergeometric functions are useful in constructing so-called conformal mappings of polygonal regions whose sides are circular arcs. Learn More in these related Britannica articles:

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Special functions are particular mathematical functions which have more or less established names and notations due to their importance in mathematical analysis, functional analysis, physics, or other applications.

Evaluation of special functions[edit] Most special functions are considered as a function of a complex variable. They are analytic ; the singularities and cuts are described; the differential and integral representations are known and the expansion to the Taylor series or asymptotic series are available. In addition, sometimes there exist relations with other special functions; a complicated special function can be expressed in terms of simpler functions. Various representations can be used for the evaluation; the simplest way to evaluate a function is to expand it into a Taylor series. However, such representation may converge slowly if at all. In algorithmic languages, rational approximations are typically used, although they may behave badly in the case of complex argument s. The high point of special function theory in the period was the theory of elliptic functions ; treatises that were essentially complete, such as that of Tannery and Molk , could be written as handbooks to all the basic identities of the theory. They were based on techniques from complex analysis. From that time onwards it would be assumed that analytic function theory, which had already unified the trigonometric and exponential functions , was a fundamental tool. The end of the century also saw a very detailed discussion of spherical harmonics. Changing and fixed motivations[edit] Of course the wish for a broad theory including as many as possible of the known special functions has its intellectual appeal, but it is worth noting other motivations. For a long time, the special functions were in the particular province of applied mathematics ; applications to the physical sciences and engineering determined the relative importance of functions. In the days before the electronic computer , the ultimate compliment to a special function was the computation, by hand, of extended tables of its values. This was a capital-intensive process, intended to make the function available by look-up , as for the familiar logarithm tables. The aspects of the theory that then mattered might then be two: In contrast, one might say, there are approaches typical of the interests of pure mathematics: There is not a real conflict between these approaches, in fact. Twentieth century[edit] The twentieth century saw several waves of interest in special function theory. The classic Whittaker and Watson textbook sought to unify the theory by using complex variables ; the G. Watson tome A Treatise on the Theory of Bessel Functions pushed the techniques as far as possible for one important type that particularly admitted asymptotics to be studied. Contemporary theories[edit] The modern theory of orthogonal polynomials is of a definite but limited scope. Hypergeometric series became an intricate theory, in need of later conceptual arrangement. Lie groups , and in particular their representation theory , explain what a spherical function can be in general; from onwards substantial parts of classical theory could be recast in terms of Lie groups. Further, work on algebraic combinatorics also revived interest in older parts of the theory. Conjectures of Ian G. Macdonald helped to open up large and active new fields with the typical special function flavour. Difference equations have begun to take their place besides differential equations as a source for special functions. Special functions in number theory[edit] In number theory , certain special functions have traditionally been studied, such as particular Dirichlet series and modular forms. Almost all aspects of special function theory are reflected there, as well as some new ones, such as came out of the monstrous moonshine theory.

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Preface These are the lecture notes of the lecture about special functions and their applications in mathematical (geo-)physics that took place in the summer term at the university.

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