ON THE FOURIER TRANSFORM IN MATHEMATICS AND ITS APPLICATIONS IN THIS FIELD

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ANNOTATION: *In this article, a study was conducted to collect information about one of the most important topics in mathematics - the Fourier series and its practical applications. Scientific articles and works of Uzbek and foreign scientists, as well as Internet sources, were studied and analyzed and a number of conclusions were drawn about the Fourier transform and its applications. It is analyzed from a mathematical point of view and opinions are expressed about which class of functions the replacement can be applied to.*

KEY WORDS: *operator, function, Bessel function, probability theory, Fourier-Stieltis transform, differential and integral equations, thermal conductivity, thermal energy.*

Many examples and problems related to the Fourier transform are described. However, there are few opinions about their practical application. Therefore, in this article we will present information about the practical application of the Fourier transform, rather than the theoretical part.

Let us define the Fourier permutation. The Fourier transform is a mathematical technique used to analyze signals. This allows data to be transferred from the time domain to the frequency domain by decomposing it into components.

The Fourier transform was discovered by the French mathematician Jean-Baptiste Fourier. The substitution later named after him was originally used to describe the mechanism of heat transfer. In addition, it is widely used in the mathematical theory of determining the roots of algebraic equations.

The Fourier transform operator can be applied to a more general class of functions than integrable functions, for example to some generalized (slowly increasing) functions. Fourier transforms are generalized to Bessel functions. Also, an example of this is the Fourier-Stieltjes transform, which is widely used in probability theory. Fourier transforms were first used in the theory of heat transfer, and later they are used in many important areas of mathematics: in solving differential and integral equations, in the theory of special functions, etc.

Applications of Fourier transform. The transformation of sound waves or other oscillatory processes (from light radiation and ocean waves to periods of stellar or solar activity) can also be carried out using mathematical methods. Thus, using these methods, it is possible to separate functions by expressing oscillatory processes in the form of a set of sinusoidal components, i.e., wave curves.

The Fourier transform is a very powerful tool used in various fields of science. In some cases, it is used as a tool for solving very complex equations that describe dynamic processes that occur under the influence of light, heat or electricity. In other cases, this makes it possible to detect regular components in complex vibrational signals, which can be used to correctly interpret various experimental observations in chemistry, medicine and astronomy.

Let's look at another practical application of the Fourier transform. To do this, it is necessary to conduct the following experiment. Part of the ring was heated and covered with fine sand. After this, he takes temperature measurements on the opposite side. Initially, the heat distribution is uneven: one part of the ring is cold and the other is hot, and a sharp temperature gradient can be observed between these zones. However, as heat spreads across the entire surface of the metal, it becomes more uniform. Thus, the process soon takes the form of a sine wave. Initially, the graph smoothly increases and decreases smoothly according to the laws of changing the cosine or sine function. The wave gradually decreases, and as a result the temperature is the same over the entire surface of the ring.

Now we will answer another question here. If the function in the Fourier transform consists of the sum of sine and cosine functions, that is, periodic functions, then the question arises whether the transformation is suitable only for trigonometric functions. It is worth saying that the period of the sine and cosine functions involved in the summation decreases, and their period tends to zero when infinite sums are obtained (see Figure 1). This does not mean that substitution is only suitable for trigonometric functions.

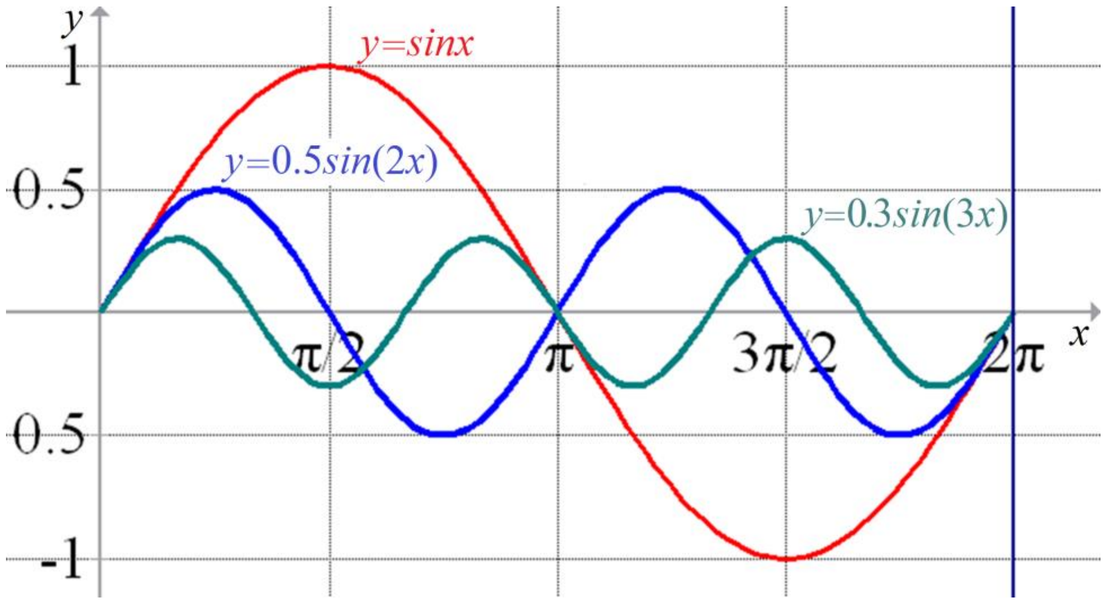

Figure 1.

Applying the above analysis to the change in heat transfer through a ring-shaped solid, it can be assumed that an increase in the periods of the mathematical sinusoidal component leads to its rapid attenuation.

The Fourier transform algorithm challenged the theoretical foundations of mathematics at the time. At the beginning of the 19th century, major scientists, including Lagrange, Laplace, Poisson, Legendre and Biot, did not accept his assertion that the original temperature distribution was decomposed into components in the form of fundamental harmonics and higher frequencies. However, the Academy of Sciences could not ignore the results obtained and awarded him a prize for the theory of the laws of thermal conductivity, as well as for comparison with physical experiments.

The Fourier transform is used in various fields: number theory, physics, signal processing, combinatorics, probability theory, cryptography, statistics, oceanology, optics, acoustics, geometry, etc. Its rich application possibilities are based on a number of useful properties, which are called “properties of the Fourier transform”[2]:

- the transformation of a function is a linear operator and unitary under appropriate normalization. This property is known as Parseval's theorem or, more generally, Plancherel's theorem or Pontryagin's dualism.

- expressions with a sinusoidal basis are characteristic differential functions. This means that this representation transforms linear equations with constant coefficients into simple algebraic equations.

- According to the Convolution Theorem, this process turns a complex operation into an elementary multiplication.

- The discrete Fourier transform can be quickly calculated on a computer using the “fast” method.

In addition, today the Fourier method occupies a strong place in various fields of science. For example, in 1962, the double helix shape of DNA was discovered using Fourier analysis combined with X-ray diffraction. Fourier transforms play an important role in space exploration, semiconductor and plasma physics, microwave acoustics, oceanography, radar, seismology, and medical research.

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