**UNCERTAINTY PRINCIPLE**

In Quantum mechanics, the uncertainty principle (also known as Heisenberg’s Uncertainty Principle) is any of a variety of the mathematical inequalities, asserting a fundamental limit to the accuracy, with which the values for certain pairs of physical quantities of a particle such as position and momentum can be predicted from initial conditions. Such variable pairs are known as complementary variables or canonically conjugate variables and depending on interpretation, the uncertainty principle limits to what extent such as conjugate properties maintain their approximate meaning, as the mathematical framework of Quantum Physics does not support the notion of simultaneously well-defined conjugate properties expressed by a single value. The uncertainty principle implies that it is in general not possible to predict the value of a quantity with arbitrary certainty, even if all initial conditions are specialized. Heisenberg’s Uncertainty Principle states that there is inherent uncertainty in the act of measuring a variable of a particle. Commonly applied to the position and momentum of a particle, the principle states that the more precisely the position is known the more uncertain the momentum is and viceversa. Heisenberg’s Uncertainty Principle is a key principle of quantum mechanics. Very roughly it states that if we know everything about where a particle is located, the uncertainty of position is small, we know nothing about its momentum where the uncertainty of momentum is large and viceversa.

Introduced first in 1927, by the German Physicist Werner Heisenberg, the uncertainty principle states that the more precisely the position of some particle is determined, the less precisely its momentum can be predicted from initial conditions and viceversa. The formal inequality relating the standard deviation of position and the standard deviation of momentum was derived by Earle Hesse Kennard later that year by Hermann Wey in 1928. Thus the product of standard deviation of position and the standard deviation of momentum is greater than and equal to half of the value of reduced Planck constant. Historically, the Uncertainty Principle has been confused with a related effect in Physics, called the observer effect, which notes that measurements of certain systems cannot be made without affecting the system, that is, without changing something in a system. Heisenberg utilised such an observer effect at the quantum level as a physical explanation of quantum uncertainty. It has since some clearer, however that the uncertainty principle is inherent in the properties of all wave-like systems and that it arises in Quantum Mechanics, simply due to the matter-wave nature of all quantum objects. Thus, the uncertainty principle actually states a fundamental property of quantum systems and is not a statement about the observational success of current technology. It must be emphasized that measurement does not mean only a process in which a physicist-observer takes part, but rather any interaction between classical and quantum objects regardless of any observer.

Since the uncertainty principle is a very basic result in quantum mechanics, typical experiments in quantum mechanics routinely observe the aspects of it. Certain experiments however may deliberately test a particular form of the uncertainty principle as part of their main research program. These include tests of number-phase uncertainty relations in superconducting or systems of quantum optics. Applications dependent on the uncertainty principle for their operation, include extremely low-noise technology such that required in gravitational wave interferometers.

The uncertainty principle is not readily apparent on the macroscopic scales of everyday experience. So, it is helpful to demonstrate how it applies to more easily understood physical situations. Two alternative frameworks for quantum physics offer different explanations for the uncertainty principle. The wave mechanics picture of the uncertainty principle is more visually intuitive, but the more abstract matrix mechanics picture formulates it in a way that generalizes more easily. Mathematically, in wave mechanics, the uncertainty relation between position and momentum arises because the expressions of the wave function in the two corresponding orthonormal bases in Hilbert space are Fourier transforms of one another (i.e. position and momentum are conjugate variables). A non-zero function and its Fourier transform cannot both be sharply localized at the same time. A similar tradeoff between the variances of Fourier conjugates arises in all systems underlain by Fourier analysis.

Applications dependent on the uncertainty principle for their operation include extremely low-noise technology such as that required in gravitational wave interferometers. Heisenberg’s uncertainty principle states that it is impossible to determine simultaneously the exact position and exact momentum (or velocity) of an electron. Thus, uncertainty principle is not applicable to stationary electron because when the electron is stationary, its velocity is zero. Thus the detection of electron would be made by way of its interaction with photons of light – this reflected photon causes a change in the path of the electron. From this principle it can be proved that electrons are not present within atomic nucleus – other than that Quantum Mechanics, Wave Mechanics and the current scientific understanding of atom is shaped properly. The uncertainty principle is only applicable at the atomic level as it explains the reason for not determining both precise velocity and position of a particle. Heisenberg’s uncertainty principle is one of the most celebrated results of quantum mechanics and states that one cannot know all things about a particle, as being defined by wave-functions at the same time - this principle is mathematically manifested as non-commuting operators. This principle states that this is an inherent uncertainty in the act of measuring the variable of a particle. If applied to the position and momentum of a particle, the principle states that the more precisely the position is known, the more uncertain the momentum is and viceversa. Heisenberg’s uncertainty principle is not applicable to any macroscopic objects, because of not having any observable properties.