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Quantum mechanics is the branch of physics that studies the behavior of the smallest particles in the universe, such as electrons, photons, and atoms. Unlike larger objects that follow classical physics rules, these particles behave in strange and unpredictable ways. A Brief HistoryThe field emerged in the early 20th century with groundbreaking work by scientists like Max Planck, Albert Einstein, and Niels Bohr. Core Quantum Concepts Explained Simply1. Wave-Particle DualityImagine light behaving both as a particle (like a tiny solid object) and a wave (like a ripple in water). Depending on how you observe it, light can switch between these behaviors. 2. SuperpositionThink of a spinning coin in the air—it's neither heads nor tails until it lands. Similarly, quantum particles can exist in multiple states simultaneously until observed. 3. EntanglementTwo particles become linked so that the state of one instantly affects the other, even if they're light-years apart. Albert Einstein famously called this "spooky action at a distance." 4. Heisenberg Uncertainty PrincipleYou can't know both the exact position and speed of a quantum particle at the same time. It's like trying to capture a clear photograph of a moving car. Why Quantum Mechanics Matters: Real-World Applications1. Technology/Semiconductors: Essential for microchips in smartphones and laptops. 2. Lasers: Used in everything from barcode scanners to medical treatments. 3. Quantum Computing: Promises faster problem-solving than classical computers. 4. Medical Imaging: MRI machines use quantum principles. 5. Solar Panels: Rely on quantum mechanics to convert sunlight into electricity. FAQAbout Quantum MechanicsWhat is quantum mechanics in simple terms?Quantum mechanics is the study of how the smallest particles in the universe behave. Is quantum mechanics hard to understand?While some concepts are complex, breaking them down into simple terms can help. Can quantum mechanics be used for time travel?Current quantum theories do not support practical time travel. Quantum mechanics may seem intimidating, but understanding its principles can open up new perspectives on science and technology. From smartphones to the mysteries of the cosmos, quantum mechanics shapes the modern world. At the smallest scales, the universe behaves very differently than the everyday world we observe around us. Quantum mechanics is the subfield of physics that describes this bizarre behavior of microscopic particles atoms, electrons, photons and almost everything else in the molecular and submolecular realm. Developed during the first half of the 20th century, the results of quantum mechanics are often extremely strange and counterintuitive. However, studying them has allowed physicists to reach a greater understanding about the nature of the universe, and could one day change the way we as humans process information. How is quantum mechanics different from classical physics? At the scale of atoms and electrons, many of the equations of classical mechanics, which describe the movement and interactions of things at everyday sizes and speeds, cease to be useful. You can't use classical mechanics, objects exist in a specific place at a specific time. In quantum mechanics, objects instead exist in a haze of probability; they have a certain chance of being at point A, another chance of being at point B and so on. Unlike Albert Einstein's famous theory of relativity, which was developed at the turn of the 20th century, quantum mechanics is still being refined. One of the most famous experiments in quantum mechanics is the double-slit experiment, which was first performed by Thomas Young in 1801. It demonstrated that light, which we know to be a wave, can also behave like a particle. This was a major breakthrough in understanding the nature of light, and it paved the way for the development of quantum mechanics. Today, quantum mechanics is used to explain why objects at specific temperatures, like the 1,470-degree-Fahrenheit (800 degrees Celsius) filament of a light bulb, glow a specific color in this case, red, according to the Perimeter Institute. Planck realized that equations used by physicist Ludwig Boltzmann to describe the behavior of gases could be translated into an explanation for this relationship between temperature and color. The problem was that Boltzmann's work relied on the fact that any given gas was made from tiny particles, meaning that light, too, was made from discrete bits. This idea flew in the face of ideas about light at the time, when most physicists believed that light was a continuous wave and not a tiny packet. Planck himself didn't believe in either atoms or discrete bits of light, but his concept was given a boost in 1905, when Einstein published a paper, "Concerning an Heuristic Point of View Toward the Emission and Transformation of Light." Einstein envisioned light traveling not as a wave, but as some manner of "energy quanta." This packet of energy, Einstein suggested in his paper, could "be absorbed or generated only as a whole," specifically when an atom "jumps" between quantized vibration rates. This is where the "quantum" part of quantum mechanics comes from. With this new way to conceive of light, Einstein offered insights into the behavior of nine phenomena in his paper, including the specific colors that Planck described being emitted from a light bulb filament. It also explained how certain colors of light could eject electrons off metal surfaces a phenomenon known as the photoelectric effect. What is wave-particle duality? Here is a diagram of the double-slit experiment where electrons produce a wave pattern when two slits are used. (Image credit: grayjay via Shutterstock)In quantum mechanics, particles can sometimes exist as waves and sometimes exist as particles. This can be most famously seen in the double-slit experiment, where particles such as electrons are shot at a board with two slits cut into it, behind which sits a screen that lights up when an electron hits. If the electrons are sent one at a time, the pattern that builds up on the screen is a series of light and dark bands, just like the interference pattern of waves. But if the electrons are sent in a bunch, the pattern is a series of light and dark bands, just like the interference pattern of waves. This is because the electrons are behaving like waves when they pass through the slits, but they are behaving like particles when they hit the screen. This is a fundamental property of nature, and it is one of the most important principles of quantum mechanics. The uncertainty principle is a fundamental principle of quantum mechanics that states that certain pairs of properties, such as position and momentum, cannot both be precisely known at the same time. The more accurately you know one of the properties, the less accurately you can know the other. This is not just a limitation of our measurement tools, but a fundamental property of nature itself. It is a consequence of the wave-like nature of particles, and it is a key feature of quantum mechanics. The uncertainty principle is a cornerstone of quantum mechanics, and it has led to many of the most important discoveries in the field. It is a principle that has shaped our understanding of the universe at the smallest scales, and it is a principle that continues to shape our understanding of the universe today. 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One atom decays, the mechanism releases photon, killing the cat. If not, the cat lives. According to quantum mechanics, until we open the box and observe it, the cat is in a superposition of being both alive and dead. Only observation collapses the superposition into one definite state. While Schrödinger calls it a metaphor, experiments on real quantum particles have found it spits-out the same particle, instantly and without communication, as if he found split, even if they were light-years apart. This instantaneous connection seems to violate Einstein's belief that nothing can travel faster than light. Einstein, along with Podolsky and Rosen, published the EPR paradox paper in 1935, arguing that quantum mechanics must be incomplete. But decades later, experiments confirmed entanglements reality, suggesting that nature allows for connections beyond classical space and time. Entanglement is not only a fascinating quirk its the basis for emerging technologies like quantum teleportation and quantum cryptography. Quantum mechanics governs the microscopic world atoms, electrons, photons. Classical mechanics governs the macroscopic world planets, tennis balls, cars. But how do the two fit together? Why don't we see cats in superpositions or cars entangled with each other? The boundary between quantum and classical is still a subject of intense research. One explanation is decoherence the idea that quantum superpositions rapidly collapse into definite states when interacting with the environment. In our messy, macroscopic world full of particles and radiation, quantum effects are washed out almost instantly. Nevertheless, experiments with larger and larger quantum systems continue to push the boundary, suggesting that the quantum weirdness is not confined to the micro-world alone. Far from being a mere curiosity, quantum mechanics powers some of the most important technologies of the modern era. Transistors the building blocks of computers and smartphones rely on quantum tunneling, where electrons pass through barriers they classically shouldn't cross. Lasers, MRI machines, and even GPS systems depend on quantum effects. Now, a second quantum revolution is underway. Scientists are developing quantum computers, which use quantum bits (qubits) that can exist in superpositions of 0 and 1. A quantum computer could solve certain problems exponentially faster than classical computers, potentially revolutionizing fields from cryptography to drug discovery. Quantum sensors offer unprecedented precision, measuring things like gravity and time with accuracy previously unimaginable. Spectacularly well in practice. But what it says about reality remains deeply puzzling, leading to many competing interpretations. The Copenhagen interpretation, championed by Niels Bohr, holds that quantum systems exist in superpositions until observed, at which point the wavefunction collapses. The Many Worlds Interpretation, proposed by Hugh Everett, suggests that every quantum event spawns new parallel universes, where every possible outcome happens. Pilot-wave theory, developed by Louis de Broglie and David Bohm, posits that particles are guided by deterministic hidden variables. Each interpretation offers a different vision of reality, yet none has been definitively proven or disproven. In quantum physics, understanding how the world works remains a profound and open question. In the mid-20th century, physicists developed quantum field theory (QFT), combining quantum mechanics with special relativity. In QFT, particles are excitations in underlying fields that pervade space. The photon is a ripple in the electromagnetic field. The Higgs boson famously discovered in 2012 is an excitation of the Higgs field, which gives particles mass. QFT forms the basis of the Standard Model of particle physics, which describes all known fundamental particles and forces (except gravity) with breathtaking accuracy. Yet, mysteries remain. Gravity still resists a quantum description. Dark matter and dark energy, which make up most of the universe, remain unexplained. The quest to unify quantum physics with Einsteins general relativity the so-called theory of everything continues. Quantum physics doesnt just challenge scientific ideas it forces us to rethink the very nature of reality. Are particles real before we observe them? Does the universe split into infinite branches with every quantum event? Is reality fundamentally deterministic or probabilistic? Is consciousness somehow involved in the collapse of the wavefunction? These questions bridge physics and philosophy, suggesting that understanding the quantum world may also require understanding the human mind. Quantum mechanics isnt just a set of rules; it's a way of seeing the world. It tells us that the universe is far stranger, more interconnected, and more mysterious than we ever imagined. As technology advances, quantum principles weave through every corner of existence. And while we have harnessed its power for technology and innovation, we are only beginning to fathom its deeper implications. For the beginner, quantum physics may seem like stepping into a dream where the rules are upside down. But as with any great journey, the more you explore, the more you realize that the quantum world, bizarre though it may be, is the foundation of everything. It is a realm where imagination meets reality, where the impossible becomes inevitable, and where the universe whispers its most profound secrets if only we are curious enough to listen. Love this? Share it! Help us spark curiosity about science!

Quantum physics is the study of matter and energy at the most fundamental level. It aims to uncover the properties and behaviors of the very building blocks of nature. While many quantum experiments examine very small objects, such as electrons and photons, quantum phenomena are all around us, acting on every scale. However, we may not be able to detect them easily in larger objects. This may give the wrong impression that quantum phenomena are bizarre or otherworldly. In fact, quantum science closes gaps in our knowledge of physics to give us a more complete picture of our everyday lives. Quantum discoveries have been incorporated into our foundational understanding of materials, chemistry, biology, and astronomy. These discoveries are a valuable resource for innovation, giving rise to devices such as lasers and transistors, and enabling real progress on technologies once considered purely speculative, such as quantum computers. Physicists are exploring the potential of quantum science to transform our view of gravity and its connection to space and time. Quantum science may even reveal everything in the universe (or in multiple universes) is connected. Everything else through higher dimensions? Our senses cannot comprehend. The word of quantum physics arose in the late 1800s and early 1900s from a series of experimental observations of atoms and molecules didn't neatly settle in the context of classical physics. Among the basic tenets of the resulting quantum reality was that matter and energy are thought of as discrete packets rather than continuous waves. For example, light of a fixed frequency delivers energy in quantized packets called photons. Each photon at this frequency will have the same amount of energy, and this energy can't be broken down into smaller units. In fact, the word "quantum" has Latin roots and means "how much." Knowledge of quantum principles transformed our conceptualization of the atom, which consists of a nucleus surrounded by electrons. Early models depicted electrons as particles that orbited the nucleus, much like the way satellites orbit Earth. Modern quantum physics instead understands electrons as being distributed within orbitals, mathematical descriptions that represent the probability of the electrons' existence in more than one location within a given range at any given time. Electrons can jump from one orbital to another as they gain or lose energy, but they cannot be found between orbitals. Other central concepts helped to establish the foundations of quantum physics: Wave-particle duality. This principle dates back to the earliest days of quantum science. It describes the outcomes of experiments that showed that light and matter had the properties of particles or waves, depending on how they were measured. Today, we understand that these different forms of energy are actually neither particle nor wave. They are distinct quantum objects that we cannot easily conceptualize. Superposition: This is a term used to describe an object as a combination of multiple possible states at the same time. A superposed object is analogous to a ripple on the surface of a pond that is a combination of two waves overlapping. In a mathematical sense, an object in superposition can be represented by an equation that has more than one solution or outcome. Uncertainty principle: This is a mathematical concept that represents a trade-off between knowing the position and momentum of a particle. The more precisely you know the position, the less precisely you can know the momentum, and vice versa. Or more objects are connected in such a way that they can be thought of as a single system, even if they are very far apart. The state of one object in that system can't be fully described without information on the state of the other object. Likewise, learning information about one object automatically tells you something about the other and vice versa. Because many of the concepts of quantum physics are difficult if not impossible for us to visualize, mathematics is essential to the field. Equations are used to describe or help predict quantum objects and phenomena in ways that are more exact than what our imaginations can conjure. Mathematics is also necessary to represent the probabilistic nature of quantum phenomena. For example, the position of an electron may not be known exactly. Instead, it may be described as being in a range of possible locations (such as within an orbital), with each location associated with a probability of finding the electron there. Given their probabilistic nature, quantum objects are often described using mathematical "wave functions," which are solutions to what is known as the Schrdinger equation. Waves in water can be characterized by the changing height of the water as the wave moves past a set point. Similarly, sound waves can be characterized by the changing compression or expansion of air molecules as they move past a point. Wave functions don't track with a physical property in this way. The solutions to the wave functions provide the likelihoods of where an observer might find a particular object over a range of potential options. However, just as a ripple in a pond or a note played on a trumpet are spread out and not confined to one location, quantum objects can also be in multiple places at once, depending on the state, as in the case of superpositional one. The act of observation is a topic of considerable discussion in quantum physics. Early in the field, scientists were baffled to find that simply observing an experiment influenced the outcome. For example, an electron acted like a wave when not observed, but the act of observing it caused it to behave like a particle. This led to the development of the uncertainty principle, which states that the more precisely you measure one property of a particle, the less precisely you can know another property. This is due to the interaction between the quantum phenomenon and the external environment, including the device used to measure the phenomenon. Even this connection has caveats, though, and a full understanding of the relationship between measurement and outcome is still needed. Credit: Joel Caswell for Caltech Science Exchange Perhaps the most definitive experiment in the field of quantum physics is the double-slit experiment. This experiment, which involves shooting particles such as photons or electrons through a barrier with two slits, was originally used in 1801 to show that light is made up of waves. Since then, numerous incarnations of the experiment have been used to demonstrate that matter can also behave like a wave and to demonstrate the principles of superposition, entanglement, and the observer effect. The field of quantum science may seem mysterious or illogical, but it describes everything around us, whether we realize it or not. Harnessing the power of quantum physics gives rise to new technologies, both for applications we use today and for those that may be available in the future. In this quantum physics introduction for beginners, we will explain quantum physics, also called quantum mechanics, in simple terms. Quantum physics is possibly the most fascinating part of physics that exists. It is the amazing physics that becomes relevant for small particles, where the so-called classical physics is no longer valid. Where classical mechanics describes the movement of sufficiently big particles, and everything is deterministic, we can only determine probabilities for the movement of very small particles, and we call the corresponding theory quantum mechanics. You may have heard Einsteins saying, Der Alte wrfelt nicht which roughly means God does not roll dice. Well, even geniuses can be wrong. Again, quantum mechanics is not deterministic, but we can in general only determine probabilities. Since we are used to reasonably big objects in our everyday life, quantum mechanics and its laws may initially seem strange and quantum theory is often considered complex. But for example, electrons and photons are sufficiently small that quantum physics is needed, and on this website, we will show you that understanding the basics of quantum physics is easy and fun. In the following paragraph, we will describe a thought experiment that we perform at two different length scales. With bullets as known from pistols (the large scale) and with electrons (the very small scale). While the experiment is essentially the same but for the size, we will show you how the result is very different. This will be your first lecture in quantum mechanics. Consider first a machine gun that fires bullets to a wall. Between the wall and the machine gun, another wall has two parallel slits that are big enough to easily allow a bullet to pass through them. To make the experiment interesting, we take a bad machine gun that has a lot of spread. This means it sometimes shoots through the first slit and sometimes through the second, and sometimes it hits the intermediate wall. If we block the second slit, all bullets that reach the outer wall will have come through the first slit. If we count the number of bullets as a function of the distance from the center of the outer wall, we will find a curve distribution that could be similar to a Gaussian curve. We can call this probability curve P1. If we block the first slit, all bullets that reach the outer wall will have come through the second slit. The probability curve will be mirrored around the center, and we call it P2. If we open both slits, all bullets at the outer wall will have come through either slit 1 or 2. Typical for classical mechanics in this situation is that the total probability distribution P can be determined as the sum of the previously-mentioned probability distributions, P = P1 + P2. Now consider the same experiment on a much smaller scale. Instead of bullets from a machine gun we consider electrons that for example can stem from a heated wire parallel to the two slits in an intermediate wall. The electron direction will have a natural spread. The slits are also much smaller than before but still big enough to let electrons pass through. If we block the second slit, we will find a probability distribution P1. If we block the first slit, we will find a probability distribution P2. If we open both slits, we expect what will happen if we do not block any slit? Will we find a probability distribution P = P1 + P2 as before? Well, after all we said you may guess that this is not the case. Indeed, we will instead find a probability distribution that has various minima and maxima. That is, for x = 0 there would be the strongest peak of electrons, for a certain +Delta x there wouldnt be any electrons at all, but for +2 Delta x there would be another peak of electrons, and so on. How can we explain these results? Well, the explanation is rather straight forward if we assume that electrons in this specific case do not behave as particles, but as waves. Waves? you may ask. Well, consider a plain of water, and the same wall as before and the same intermediate wall with a double slit as before. At the place where the machine gun or the wire where, consider a pencil punching periodically downwards into the water. If you do this, you will get concentric waves around the point where you punch the water, until the intermediate plain with the two slits. Behind each slit, there will be a half circle of concentric waves, up to the point where the new waves from the two slits cross each other. There, the waves from the two slits can add up or eliminate each other. As a function of the periodic punching you will find points where the height of the wave is always the same. There will be other places where the wave is sometimes very high and sometimes very low. At the outer wall, these two phases will be repeatedly following one another. The places where there is a lot of variation correspond to the places where there are the most electrons. The places with no variation correspond to the places where there are no electrons on the wall at all. So, why do electrons in this case behave like waves and not like particles? Well, this is the thing where you will not find a satisfying answer. You just need to accept it. What if you do not believe this? Well, the thought experiment with the electrons is rather difficult to perform with the proper scale of all elements of the experiment. But there is another very similar experiment that you can do at home. Instead of the electrons you use the photons (light particles) from a laser which you can buy for a few bucks. You let the laser shine through a double slit, darken the room, and look at the outer wall. And boom! What you see is not just two light lines on the outer wall, but a pattern of light fine, dark line, light line, dark line, and so on. The intensity of the lighter region becomes less far away from the center. It corresponds exactly to the result of our thought experiments with electrons. Why does the laser experiment give the same result as the thought experiment with electrons? It is quite easy: Light particles, called photons, are also very small and therefore behave quantum mechanically. And like electrons, they behave like waves in this specific situation. As a side remark, research has shown that light behaves like particles in another respect: If one reduces the intensity a lot, one will find single light spots from single photons on the wall. This means the light behaves like particles as well. One therefore talks about theparticle-wave dualiof photons or electrons. What do you wait for? Do the experiment, and you will become a believer of quantum mechanics, or more generally phrased, of quantum physics. The pattern with maxima and minima is called an interference pattern, since it comes about by the interference of the waves through slit 1 and slit 2. It has been found that you only get this interference pattern if you do not by other means (some additional measurement instrument) watch through which of the two slits the electrons or photons pass. If you do measure which of the two ways the particles pass by any other means, the interference pattern goes away. You will then find the sum distribution P = P1 + P2 as in the classical experiment. A measurement device for electrons would typically disturb the electrons. More precisely, their momentum would typically change due to a measurement device, while the place x of its path would become known more precisely. In general, there will be some uncertainty left in the momentum and in the place of the electron. Heisenberg postulated that the product of these uncertainties can never be lower than a specific constant h: Delta x times Delta p >= h. No one ever managed to disprove this relation, which is at the heart of quantum mechanics. Essentially it says, we cannot measure both momentum and place with arbitrary precision at the same time. We said that for proper distributions, you will find a similar result P1 and P2 as in the classical case. However, for other sizes one can achieve an interference pattern even for the single slits. This is the case when the slit is so broad that one can achieve an interference of the wave stemming from one side of the slit with the wave stemming from the other side of the slit. We said above that quantum physics becomes relevant for small particles whereby we mean thnatnaturally, quantum effects are only seen for small particles. However, the theory itself is thought to provide

entanglement. There are still some potential applications for having two particles entangled at a distance. One can use the entangled particles as a way of sharing an encryption key, for instance. But this sort of phenomenon is hardly a convincing mechanism for a metaphysical process like psychic communication or a global consciousness. "Everything is energy." [edit] More a general physics claim than one specific to quantum mechanics, it is nonetheless occasionally claimed that "Quantum physics has shown that everything is made of energy." Actually, nothing in physics is made of energy, because energy is not a substance, but rather a conserved quantity. Just as nothing is "made of" 70 liters, no one is made out of a certain amount of energy. Nor is anything made out of charge, momentum, or angular momentum. Those are simply properties of objects and systems. It is true that mass and energy can be converted into one another and thus it can be useful to think of mass as just a form of energy. However, nothing is made of mass either. Things are made out of matter, which is a generic name for all physical substances and not a quantity. Nothing is made out of mass, which is a way of quantifying matter but is not a substance any more than volume or total charge are substances. Things which we think about as being "made of energy", like light or electricity, are generally made up of particles just like everything else. There's no scientific definition of energy that can support this vague idea. "The God Particle" [edit] This is a colloquial name given to particle called the Higgs boson in a popular science book by the same name. While the book is a generally accurate overview of theoretical physics (as it was in the early 90's), the name it gives to the as-then hypothetical Higgs boson is misleading. The Higgs field would be responsible for giving mass to all particles which have non-zero mass, which is a fairly important role, but which does not necessarily have anything to do with a God. The name is a poetic metaphor which is built up during the book, and has nothing to do with the real properties of the particle or the search for it. Anyone who claims that the Higgs boson has some bearing on the existence of God almost certainly has no idea what the Higgs boson actually is. Quotes [edit] "I'm getting rather tired of Christian arm chair physicists waving their hands around in the air, muttering about the "mysteries of QM" and invoking a similar mystery for their god. If God were understood as well as quantum mechanics, we would have already miniaturized him and put him in a device to carry around on our wrists."" Ozy666 (About Atheism/Agnosticism forum) "It didn't matter that the machine had been switched off, the wizards said. It existed in plenty of other presents, and so worked here owing to a lengthy sentence, which [] had the words like "portal," "multidimensional," and "quantum" in it, "quantum" being in it twice." Terry Pratchett, Going Postal

What is quantum physics in simple words. Quantum physics explained simple. What's the definition of quantum physics. Quantum physics simple explanation. Quantum physics simply explained.