Audio Science Fundamentals - Sound Waves

Hello and welcome back to the Charles C. Lab. To talk about our first official video about this incredible journey about audio engineering and audio science, we should definitely lay down some fundamentals and what's the most fundamental thing in audio is basically understanding what sound is or specifically what sound waves are. We're going to talk about a little bit around that topic, also describe a little bit what the difference between what's called as a digital sine wave or a digital representation of a sine wave versus what the analog version of a sine wave is or what analog doesn't even mean in a very fundamental and basic way, as this is basically an introductory video to audio in general.

So let's dive right in. Okay, so we're going to talk about sine waves. So the most fundamental thing to understand is that sound waves are known scientifically as longitudinal waves, which is a very fancy term to say that they need a medium in order to propagate.

So sine waves are known as longitudinal waves and they need a medium to propagate. So if we're gonna describe more or less what a sine wave really is, we should definitely go ahead and have some sort of plot on it, a 2D plot specifically. So typically we represent sine waves where the x-axis is the time axis and the y-axis being the amplitude.

So the best sine wave that we can use to represent this is what we call a sine wave and we're going to talk about why is it so important, why sound waves are so important around audio in general, but we're just going to use it to demonstrate this. And sine waves, as the name implies, it's essentially the mathematical sine wave that anyone is taught in high school or trigonometry, so it's exactly the same mathematical representation. So again, when we talk about sine waves, they are longitudinal waves and they need three mediums to propagate.

Solid, liquids, gases. So basically at this point we understand that when we talk about audio, we typically understand audio as something that we listen and that that we listen can be described as any sort of energy or fluctuations in energy around us that need a medium to propagate. And again, one more time, solid, liquid, and gases.

So we just talk about longitudinal waves needing a medium to propagate. There's typically, let's just talk that we're in the middle of space. If we're not inside of any planet or anything, there's no air, there's no any sort of liquid.

So as it turns out, we just need any sort of gas energy. We don't necessarily need air in order to propagate sound. If there's any high density gas or any sort of high concentration of gas around space and there's any perturbations around that space area, we're gas is highly dense, then we can definitely talk about sine waves in that scenario.

We can actually, if we were to put microphones in there, we could actually listen to sounds in

space. And actually, there's a really good experiment that NASA did not that far off from the date of this video, so I'm going to post that in the description, where you can actually listen to what black holes sound like. And funny enough, when I heard about that news, the first thought came to my mind was wow, how come we can hear things in space? I thought, you know, since it's an infinite vacuum, there's no way for sounds to propagate.

But it turns out, and I learned it that way and wanted to share it to the world as well, was that so long there's a high density or some sort of gas concentration in space, we can actually hear how sounds propagate around that. And as you can imagine, it's pretty, pretty creepy actually. So yeah, definitely go ahead and check that out.

I think it's really fun. The next thing to talk about is a quick overview of what an analog signal is and what a digital signal is, just in a fundamental way and understanding basic difference around that, because it's going to lay down the fundamentals for the next videos that are come up. Okay, so let's talk about an overview between analog versus digital signals.

So essentially, we need to differentiate what analog and digital signals are. Analog are basically anything in our physical world. Sound waves are by nature analog, because there are continuous sound.

And by meaning continuous, it will make more sense once we talk about digital, but it means that there's an infinite amount of points or an infinite amount of data between a single point of the sine wave to the next one. So if we were to capture a single instance of a sound at, let's say, one millisecond, and then we're going to go to the next millisecond, the amount of data in between those two is infinite, meaning that there's no gaps between it. There's just a whole stream of data.

So an analog sine wave, it's a continuous representation of what a sound wave is. So an exact representation. That's a very basic definition of what analog is.

So for digital, we're going to take this same plot that I just showed, and we're going to basically start taking small but regular points across the x-axis. The distance between each point, when I mean regular, I mean that they have to be the same. And we're going to talk exactly about that, but this is what's called the sampling rate.

So it's a rate at which we sample an analog signal or a continuous signal. And we're going to do the exact same thing for the y-axis. This is also called quantization, and we're going to talk more about this.

But basically what we're going to do is we're going to divide our x and y-axis in regular points. And at this point, we're going to officially start taking samples from the analog or the continuous signal. So what we're going to basically be doing is in our x and y-axis, we're going to just take points.

And just for the sake of this, this would continue until the end. But then after we take all these

points, we're going to go ahead and plot them in a new plot. And so it's going to look something like this, which is going to quickly resemble the sine wave.

But instead of showing continuous information, so no gaps, we're going to start introducing some gaps between one sample and the other. And it's going to look something like this. And this is what, at the end of the day, we represent or how we represent a digital signal or a sine wave that has been digitized.

And effectively, this is how we store information in our computers. So at the end of the day, we take an analog signal, and even the basically recording as we talk is a digitization of a continuous signal, and it's been stored in the computer as samples. So here are the main two differences between an analog and digital signal, at least when it comes to representing sound waves.

So again, analog signals are continuous information. There's no gaps between one point or the other. And a digital signal is basically taking, now that we introduced the term samples, we're going to be using that, we're going to take regular samples in time, and we're going to basically be able to store this information in our computers.

So in general, sound waves are analog by nature. There's no in between one point to the other, and that's what essentially is sound, it's an analog signal. But then we can go ahead and describe it in a digital way, which as we mentioned, is taking regular samples of the analog signal, and then that information can actually be stored in our computers.

And by the way, another term that we can name these two, I can mention analogs are considered continuous signals, and digital are considered discrete time signals. So it's important to know those two can be referred as those two other names, because that's how we're going to refer them in the next videos. So there you go, guys.

So that's what the main overview of what sound waves is, what sound is, how can we represent it in a continuous and a discrete form. Again, this is the same as saying analog or a digital way of representing sound waves. We know as well that sound waves are what are referred to as longitudinal waves, which can propagate between gases, liquids, or solids.

I wanted to post this quick lecture video about what sound waves are, and a quick overview between analog and digital, because it's, I think it's going to be a really fundamental, and it's going to lay down fundamentals to talk about the next topics around audio in general. So that's everything for today, folks. I hope that you guys liked it, and if you did like it, please leave a thumbs up and consider subscribing, and I'll see you in the next video.

Thank you.