



#2 on Trending

### The Most Important Algorithm Of All Time

**Veritasium** 13M subscribers

Subscribed Download As: ▼

93K Share Clip Save More

1,524,874 views Nov 3, 2022

The Fast Fourier Transform is used everywhere but it has a fascinating origin story that could have ended the nuclear arms race. This video is sponsored by 80,000 Hours. Head to <http://80000hours.org/veritasium> to sign up for their newsletter and get sent a free copy of their in-depth career guide.

A huge thank you to Dr. Richard Garwin for taking the time to speak with us. Thanks to Dr. Steve Brunton of the University of Washington for his help with understanding the Fast Fourier Transform.

Thanks to Dr. Cliff Thurber of the University of Wisconsin-Madison, Dr. Paul Richards of Columbia University, and Dr. Steven Gibbons of the Norwegian Geotechnical Institute for their expertise.

Thanks to Grant Sanderson of 3Blue1Brown for his helpful feedback on the script. His great video on the Fourier Transform is here - <https://youtu.be/spUNpyF58BY>

References:

Kristensen, H.M., Korda, M. (2022). Status of World Nuclear Forces. Federation of American Scientists (FAS). <https://ve42.co/Stockpile2022>

Barth, K. H. (1998). Science and politics in early nuclear test ban negotiations. Physics Today, 51(3), 34-39. - <https://ve42.co/Barth1998>

Schmalberger, T. (1991). In pursuit of a nuclear test ban treaty - <https://ve42.co/Schmalberger1991>

Bowers, D., & Selby, N. D. (2009). Forensic seismology and the comprehensive nuclear-test-ban treaty. Annual Review of Earth and Planetary Sciences, 37, 209-236 - <https://ve42.co/Bowers2009>

Incorporated Research Institutions for Seismology (IRIS). (2022). How Often Do Earthquakes Occur? <https://ve42.co/IRIS2022>

Kimball, D. (2022). The Nuclear Testing Tally. Arms Control Association. <https://ve42.co/TestTally2022>

Kvaerna, T., & Ringdal, F. (2013). Detection capability of the seismic network of the International Monitoring System for the Comprehensive Nuclear Test Ban Treaty. Bulletin of the Seismological Society of America, 103(2A), 759-772 - <https://ve42.co/Kvrma2013>

Sykes, L. R., & Evernden, J. F. (1982). The verification of a comprehensive nuclear test ban. Scientific American, 247(4), 47-55 - <https://ve42.co/Sykes1982>

Peterson, J., & Hutt, C. R. (2014). World-wide standardized seismograph network: a data users guide (p. 82). US Department of the Interior, US Geological Survey. - <https://ve42.co/Peterson2014>

Richards, P. G., & Kim, W. Y. (2009). Monitoring for nuclear explosions. Scientific American, 300(3), 70-77 - <https://ve42.co/Richards2009>

Jacobsen, L. L., Fedorova, I., & Lajus, J. (2021). The seismograph as a diplomatic object: The Soviet–American exchange of instruments, 1958–1964. Centaurus, 63(2), 277-295 - <https://ve42.co/Jacobsen2021>

Schwartz S. I. (1998). The Hidden Costs Of Our Nuclear Arsenal: Overview Of Project Findings. The Brookings Institution - <https://ve42.co/Schwartz1998>

Ricón, J.L. (2016). The Soviet Union: Military Spending. Nintil - <https://ve42.co/Nintil2016>

Heideman, M. T., Johnson, D. H., & Burrus, C. S. (1985). Gauss and the history of the fast Fourier transform. Archive for history of exact sciences, 265-277 - <https://ve42.co/Heideman1985>

Ford, D. (2004). Richard Garwin - Session IV. American Institute of Physics (AIP). - <https://ve42.co/Ford2004>

Aaserud, F. (1986). Richard Garwin - Session I. American Institute of Physics (AIP). - <https://ve42.co/Aaserud1986>

Goldstein, A. (1997). James W. Cooley, an oral history. IEEE History Center, Piscataway, NJ, USA - <https://ve42.co/Goldstein1997>

Cooley, J., Garwin, R., Rader, C., Bogert, B., & Stockham, T. (1969). The 1968 Arden House workshop on fast Fourier transform processing. IEEE Transactions on Audio and Electroacoustics, 17(2), 66-76 - <https://ve42.co/Cooley1969>

Special thanks to Patreon supporters: Louis Lebbos, Elliot Miller, RayJ Johnson, Brian Busbee, Jerome Barakos M.D., Amadeo Bee, TTST, Balkrishna Heroor, Chris LaClair, John H. Austin, Jr., OnlineBookClub.org, Matthew Gonzalez, Eric Sexton, John Kiehl, Diffbot, Gnare, Dave Kircher, Burt Humburg, Blake Byers, Dumky, Evgeny Skvortsov, MeeKay, Bill Linder, Paul Peijzel, Josh Hibschman, Mac Malkawi, Mike Schneider, John Bauer, jim buckmaster, Juan Benet, Sunil Nagaraj, Richard Sundvall, Lee Redden, Stephen Wilcox, Marinus Kuivenhoven, Michael Krugman, Cy 'kkm' K'Nelson, Sam Lutfi, Ron Neal

Written by Derek Muller & Felicity Nelson  
 Filmed by Derek Muller & Raquel Nuno  
 Animation by Ivy Tello, Jakub Misiek, Alex Drakoulis, and Fabio Albertelli  
 Edited by Albert Leung & Derek Muller  
 Research Assistant: Katie Barnshaw  
 Additional video/photos supplied by Pond5 and Getty Images  
 Music from Epidemic Sound  
 Produced by Derek Muller, Petr Lebedev, and Emily Zhang

Show less

4,186 Comments Sort by

Add a comment...

**Veritasium** 21 hours ago

If you're thinking about how to make a positive impact with your work, get a free in-depth career guide from 80,000 Hours: [80000hours.org/veritasium](http://80000hours.org/veritasium)

593 Reply 30 replies

**Developer Steve** 22 hours ago

I really can't overstate how appreciative I am of these science history videos. It's easy in the STEM fields to forget the history soaked into the ideas we take for granted every day. I would like if Math classes gave a little glimpse into this - especially in primary schools. Maybe more kids would appreciate the importance of math and "when we would ever need this in real life".

3.3K Reply 39 replies

**ManWithBeard1990** 14 hours ago

A quick note on image compression: because of the  $n \log(n)$  complexity of the FFT it's common to divide the image up into smaller chunks. That's why on poorly compressed images or videos you tend to see blockiness. Now, what's interesting is that when you do that, instead of an FFT it often makes more sense to perform what's called a discrete cosine transform, or DCT, on those tiles. The reason for that is that in less detailed parts of the image, the most prominent components of a tile will be the average colour and an overall colour gradient. In a DCT, that information is mostly contained within the DC component and the first cosine coefficient, whereas in an FFT that information is more ...

171 Reply 6 replies

**Konstantinos Vasios** 14 hours ago (edited)

I studied Electrical & Computer Engineering. Needless to say Fourier Transform was our bread and butter. It is such a pity that usually the historical context is missing in the educational process. It helps so much put things into perspective and get a sense of the purpose and the significance of what you are being taught. I know so many students that are getting discouraged and disappointed just because the educational process only involves sterile mathematics brutally being thrown into your face without any context whatsoever.

163 Reply 3 replies

**paul broadley** 16 hours ago

Taking a complex problem, and decomposing it into the history, science and specific use cases is refreshing to see and should be explored more often in STEM education. Thanks Derek, and the team!

289 Reply 3 replies

**Michael Kelly** 13 hours ago

You've made some really great videos, but this is your masterpiece (I say that as a retired engineer who studies math and uses Maple recreationally). I knew of Garwin and Tuckey's contributions at the surface level, but the depth of your research was amazing (actually talking to Garwin was really cool). Even more astonishing was Gauss' discovery of the FFT. He is widely regarded as the greatest mathematician of all time, a title disputed by devotees of Euler. Gauss had an aversion to publishing his results until he considered them perfect, and above criticism: his personal motto was "Pauca sed matura", meaning "few, but ripe", describing his publishing habits. Euler, on the othe...

83 Reply 3 replies

**ElectroBOOM** 15 hours ago

2:16 I'm just happy the nuclear fallout stopped at the Canadian border, otherwise we could have had it bad here too! 😊

89 Reply 10 replies

**Davide** 1 day ago

I can't believe how intelligent Gauss was, it's just incredible

All Listenable Related From Veritasium >

**Why Did Quantum Entanglement Win the Nobel...**  
 PBS Space Time 675K views · 8 days ago

**The lab leak deception**  
 ReasonTV 98K views · 23 hours ago  
 New

**Positive Mood Jazz: Elegant Jazz & Bossa Nova music to...**  
 Cozy Jazz Music 164 watching  
 LIVE

**Mix - Veritasium**  
 More from this channel for you

**How Covid Changed Everything--Jeffrey Tucker**  
 Hillsdale Praxis 2.8K views · 10 days ago

**Pelosi Attack Caught on Capitol Police Video We Also Can't Se...**  
 Matt Christiansen 1.7K views · 20 minutes ago  
 New

**Truss text. Sunak, one week as UK Prime Minister**  
 The Duran 102K views · 1 day ago  
 New

**The 4 things it takes to be an expert**  
 Veritasium 6.9M views · 3 months ago

**Tucker Carlson: Isn't this supposed to be a meritocracy?**  
 Fox News 830K views · 2 days ago  
 New

**Why a Huge Chunk Of Earth's History Is Missing**  
 Thoughty2 696K views · 2 days ago  
 New

**How Imaginary Numbers Were Invented**  
 Veritasium 13M views · 1 year ago

**Bell's Inequality: The weirdest theorem in the world | Nobel...**  
 Qiskit 940K views · 3 weeks ago

**"Make Peace Non-Partisan" - GOP House Candidate Joe Kent**  
 The Grayzone 7.2K views · 16 hours ago  
 New

**The Big Misconception About Electricity**  
 Veritasium 16M views · 11 months ago

**Gutfield: Supreme Court tackles affirmative action**  
 Fox News 340K views · 1 day ago  
 New

**How Horses Save Humans From Snakebites**  
 Veritasium 12M views · 7 months ago

**The Man Who Killed Millions and Saved Billions**  
 Veritasium 14M views · 3 months ago

**The Riddle That Seems Impossible Even If You Know...**  
 Veritasium 8M views · 4 months ago

**Politics: Tradition and Vision | Newt Gingrich | #301**  
 Jordan B Peterson 228K views · 3 days ago  
 New

**How did they actually take this picture? (Very Long Baseline...**  
 Veritasium 4.5M views · 5 months ago