The Latticework:

Physics

What I noted since the really big ideas carry 95% of the freight, it wasn't at all hard for me to pick up all the big ideas from all the big disciplines and make them a standard part of my mental routines. Once you have the ideas, of course, they are no good if you don't practice – if you don't practice you lose it. So, I went through life constantly practicing this model of the multidisciplinary approach. Well, I can't tell you what that's done for me. It's made life more fun, it's made me more constructive, it's made me more helpful to others, it's made me enormously rich, you name it, that attitude really helps…

…It doesn't help you just to know them enough just so you can give them back on an exam and get an A. You have to learn these things in such a way that they're in a mental latticework in your head and you automatically use them for the rest of your life.

– Charlie Munger,

2007 USC Gould School of Law Commencement Speech

Physics

After the meta-learning principles we discussed in Worldly Wisdom, we will be diving into physics.

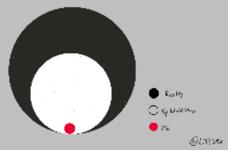
Physics investigates how matter and energy interact which helps us understand how the universe around us works. These core principles dictate how everything from subatomic particles to planets move, react, and interact with the matter and energy around it.

> Physics is the most fundamental and all-inclusive of the sciences and has had a profound effect on all scientific development. In fact, physics is the present-day equivalent of what used to be called natural philosophy, from which most of our modern sciences arose. Students of many fields find themselves studying physics because of the basic role it plays in all phenomena.
>
> – Richard Feynman, *Six Easy Pieces*

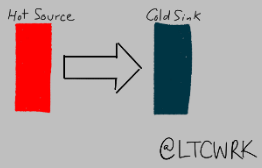
Physics is the keystone of our first bucket, serving as a primary filter in which to view the world. As we understand the facts today, these big ideas from physics have held true for 13.7 billion years and contain the largest relevant data set. These fundamental concepts are time-invariant and permeate every facet of scientific development and of our lives. This is why coming to understand the ideas, language, and sound theory of physics can help add context, color, and depth to the rest of our journey. If properly approached, it can train us to be thorough thinkers who deeply understand the laws which underpin our physical world, giving us a robust foundation to build our latticework upon.

The Big Ideas of Physics:

1. Galilean Relativity



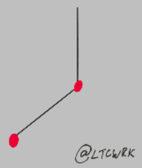
2. The Laws of Thermodynamics



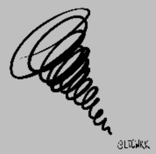
3. Newton's Laws of Motion

4. Complexity

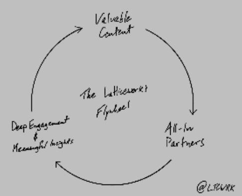
5. Chaos Theory



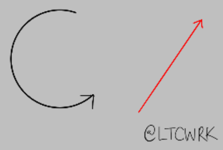
6. Emergence



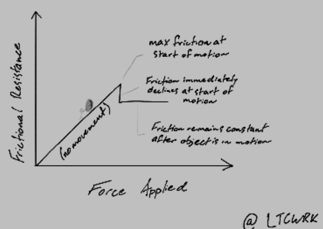
7. Momentum



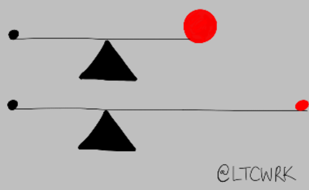
8. Velocity



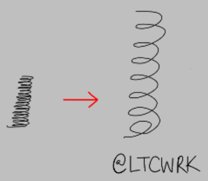
9. Friction



10. Equilibrium



11. Hysteresis



Galilean Relativity

Galilean Relativity states that we can never fully grasp, define, or understand a system we are part of. This is to say, "distance provides perspective" and wisdom in life is often about perspective.

We can escape Galilean Relativity by stepping out of our system. This "fresh set of eyes" allows us to gain perspective and to see problems for what they are. Theoretically, if we can overcome Galilean Relativity, eliminating our blindspots, we'll also eliminate our mistakes – as all mistakes come from blindspots.

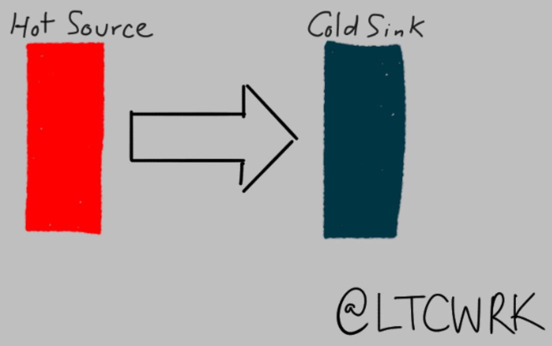
There is more than one way to look at any situation, namely one where we are NOT the center of the universe – I'm operating on the automatic, unconscious belief that I am the center of the world, and that my immediate needs and feelings are what should determine the world's priorities. The thing is that, of course, there are totally different ways to think about these kinds of situations. In this traffic, all these vehicles stopped and idling in my way, it's not impossible that some of these people in SUV's have been in horrible auto accidents in the past, and now find driving so terrifying that their therapist has all but ordered them to get a huge, heavy SUV so they can feel safe enough to drive. Or that the Hummer that just cut me off is maybe being driven by a father whose little child is hurt or sick in the seat next to him, and he's trying to get this kid to the hospital, and he's in a bigger, more legitimate hurry than I am: it is actually I who am in HIS way.

– David Foster Wallace, This is Water

The Laws of Thermodynamics

Thermodynamics is the study of the large-scale behavior of systems exchanging work and heat with connected systems or their environment. There are *four* key laws in thermodynamics:

0. Zeroth Law – The Transitive Law (If two systems are in thermodynamic equilibrium with a third system, the two original systems are in thermal equilibrium with each other.)
1. First Law – The Law of Conservation or the "No Free Lunch" Law (energy can be transformed from one form to another, but can neither be created nor destroyed)
2. Second Law – The "Contrast Advantage" Law (While there will always be "leakage" in a system, the most efficient systems have the hottest possible source and the coldest possible sink. This is what we mean by "contrast." Finding contrast in your field allows you to differentiate yourself in a "thermodynamically efficient" manner.)
3. Third Law – The "Absolute Zero" Law (The entropy of a system approaches a constant value as the temperature reaches absolute zero.)



In every engine, there has to be a cold sink, and that at some stage of the cycle energy must be discarded into it. That little mouse of experience is nothing other than the second law of thermodynamics. All the law seems to be saying is that heat cannot be completely converted into work in a cyclic engine: some has to be discarded into a cold sink. That is, we appear to have identified a fundamental tax: Nature accepts the equivalence of heat and work, but demands a contribution whenever heat is converted into work. Note the dissymmetry. Nature does not tax the conversion of work into heat: we may fritter away our hard-won work by friction, and do so completely. It is only heat that cannot be so converted. Heat is taxed; work is not.

– PW Atkins, The Second Law

Newton's Laws of Motion

Newton's Laws of Motion are three fundamental, general laws which help describe how objects in the world move and react to forces.

1. First Law – The Inertia Law (an object at rest, stays at rest)
2. Second Law: Force = Mass * Acceleration (F = ma).
3. Third Law – The Law of Reciprocity (for every action there is an equal and opposite reaction)

My most surprising discovery: the overwhelming importance in business of an unseen force that we might call "the institutional imperative." In business school, I was given no hint of the imperative's existence and I did not intuitively understand it when I entered the business world. I thought then that decent, intelligent, and experienced managers would automatically make rational business decisions. But I learned over time that isn't' so. Instead, rationality frequently wilts when the institutional imperative comes into play. For example: (1) As if governed by Newton's first law of motion, an institution will resist any change in its current direction; (2) Just as work expands to fill available time, corporate projects or acquisitions will materialize to soak up available funds; (3) Any business craving of the leader, however, will be quickly supported by detailed rate-of-return and strategic studies prepared by his troops; and (4) The behavior of peer companies, whether they are expanding, acquiring, setting compensation, or whatever, will be mindlessly imitated.

– Warren Buffett, Berkshire Hathaway 1989 Chairman's Letter

Complexity

A complex system exhibits emergent behavior due to the collective interaction of many individual agents according to simple rules. Some common properties of complex systems include: emergent collective behavior; signaling and information processing; adaptation via learning or evolution; exhibiting non-trivial emergent and self-organizing behaviors; large variability; dynamic interactions; phase transitions.

For example, you would not be able to predict the sophisticated anthill or behavior that arise out of the collective interaction of simple, individual ants. Same can be said of schools of fish or flocks of birds.

Complex systems are sensitive to original conditions, influenced by feedback loops, and buffeted by random outside variables.

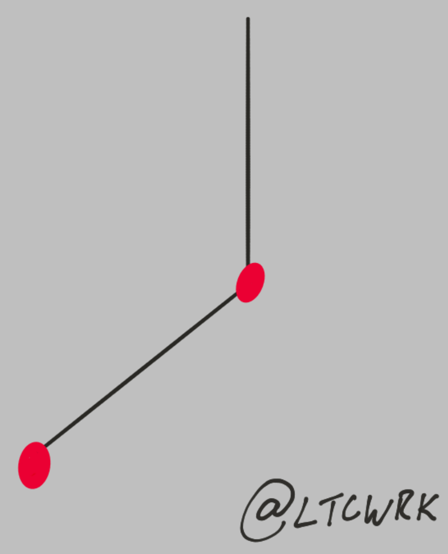
Complex systems must be studied as a whole, not in individual parts, because the behavior of the system is greater than the sum of the parts. The old science was concerned with understanding the laws of being. The new science is concerned with the laws of becoming.

– Robert Hagstrom, Latticework

Chaos Theory

The difference between chaos and complexity is subtle and important. Chaos leads to complicated, non-periodic behavior from *iteration* of a simple rule(s), whereas complexity leads to rich, collective behavior from simple *interactions* between large numbers of subunits. A double pendulum easily exemplifies the difference. Although the path is difficult to predict, it will never display emergent behavior.

Another way to think about complexity compared to chaos is along a spectrum: order – complexity – chaos. Complexity lies in between order (equilibrium, stasis) and chaos (anarchy). That is why life can be thought of as occurring at the "edge" of chaos.



Some systems are very sensitive to their starting conditions, so that the tiny difference in the initial push you give them causes a big difference in where they end up. And there is feedback, so that what a system does affects its own behavior.

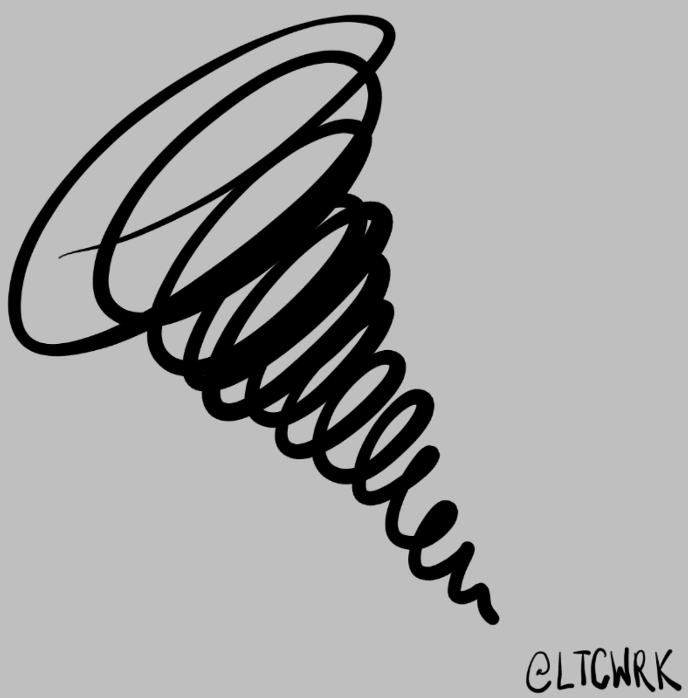
– John Gribbin, Deep Simplicity

Emergence

Emergence is a process where higher-order behavior emerges from the interaction of lower-order components.

These smaller or simpler entities do not exhibit the properties that the higher-order entity ends up exhibiting. The result is frequently not a matter of simple addition – but rather non-linear, multiplicative, or even exponential.

An important resulting property of emergent behavior is that it cannot be predicted from simply studying the component parts – the whole is greater than the sum of its parts.



It is not the amount of knowledge that makes a brain. It is not even the distribution of knowledge. It is the interconnectedness.

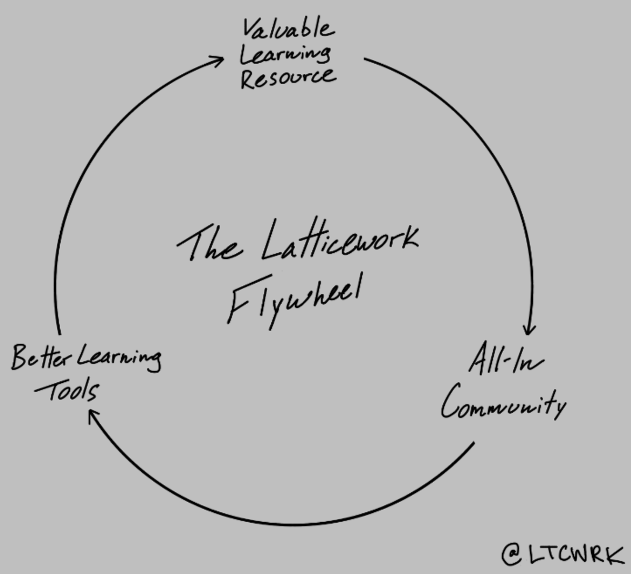
– Howard Bloom, The Lucifer Principle

Momentum

Momentum is the quantity of motion of a moving body, measured as a product of its mass and velocity: Momentum = Mass * Velocity

Momentum is broadly applicable outside of physics as it can help you understand how things change and how difficult or easy it is to change them.

The metaphor made famous by Jim Collins in *Good to Great* is that of a flywheel. A flywheel is a bit of an outdated metaphor, but the idea is time-invariant. A flywheel is a heavy revolving wheel in a machine that is used to increase the machine's momentum, giving it greater stability or a reserve of available power during interruptions in the delivery of power to the machine. Flywheels are heavy and therefore have a lot of inertia but, once they get started, quickly gain and can sustain momentum.



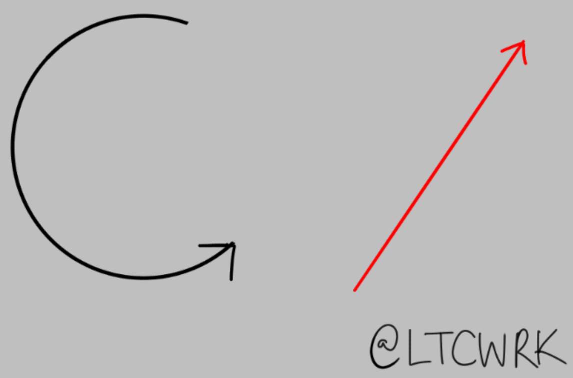
Positive feedback loops that build momentum, increasing the payoff of incremental effort. When good things you do lead to more good things "just happening."

– *Eric Jorgenson*

Velocity

There are 3 key things to deeply understand regarding velocity:

1. The difference between velocity and speed – the difference is vector. Velocity has magnitude *and* direction whereas speed does not. If you're sprinting in circles, you're clearly not going to go anywhere.
2. While nobody knows why nature favors velocity over mass, she does, and we should harness it. How do we know this? Kinetic Energy = $\frac{1}{2}mv^2$
3. The stark difference between potential energy and kinetic energy. P_e is the energy an object possesses due to its position relative to others. You can be totally still yet have potential energy (think of a car on top of a hill). K_e is energy is energy which a body possesses by virtue of being in motion. We should seek K_e



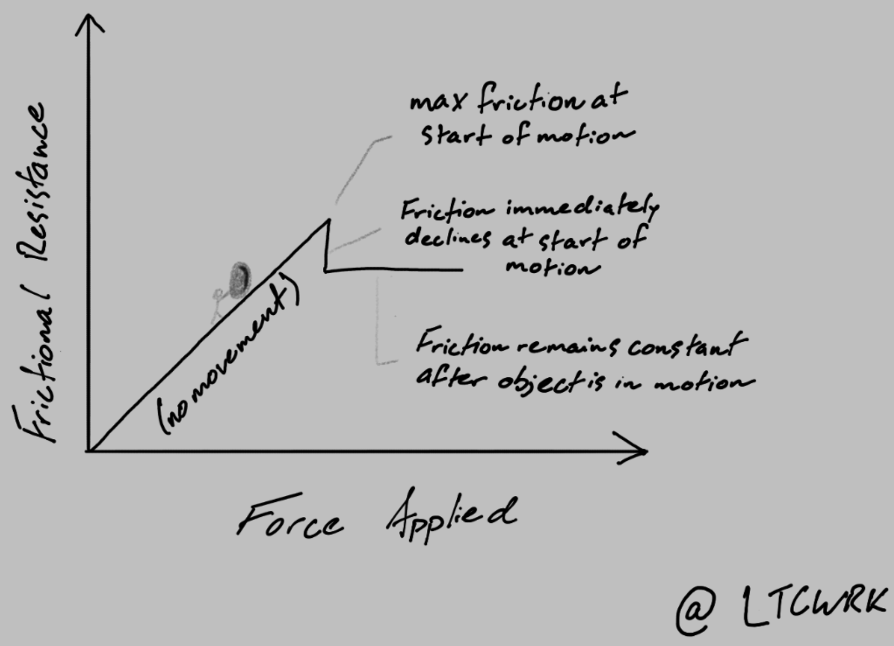
Google famously prioritized speed as a feature. They realized that if search is fast, you're more likely to search. The reason is that it encourages you to try stuff, get feedback, and try again. When a thought occurs to you, you know Google is already there. There is no delay between thought and action, no opportunity to lose the impulse to find something out. The projected cost of googling is nil. It comes to feel like an extension of your own mind…The general rule seems to be: systems which eat items quickly are fed more items. Slow systems starve.

– James Somers, Speed Matters

Friction

Friction is the force that causes the resistance felt when two objects are moving against one another.

Inertia is a prime example of friction. Take the boulder in the diagram below. It has significant inertia as it takes a lot of energy to get it moving but, once you do, its inertia will work in your favor. Although this can be daunting to overcome, be encouraged that there is typically a tipping point which, when crossed, makes change seem relatively easy.



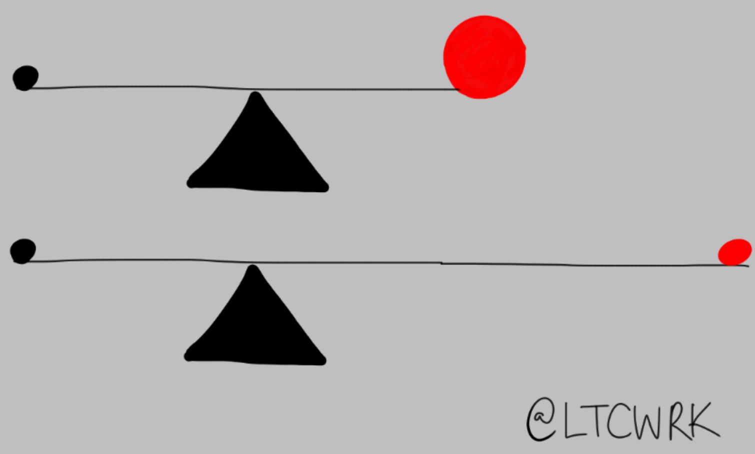
Most people, most of the time, will take whatever choice requires least work – death before inconvenience. When you understand this, you can take advantage of it – whether you're a programmer or the operator of a business. Often competitors will not be willing to put in the work required and although it is by definition difficult, it will be successful. Successful design sees through the customer's eyes and makes whatever choice they are being asked to make as simple as possible. Little nudges go a long way…

– Paul Graham, The Other Road Ahead

Equilibrium

Equilibrium is a state of balance between opposing forces, powers, or influences.

Although the idea of equilibrium might evoke an image of a static or unchanging system, that isn't always necessarily the case. In dynamic equilibrium, you have a system that stays the same though it is always changing (inflows exactly equal outflows). Imagine a whirlpool in a bathtub that can go on forever as long as the water is running, and the drain is open.



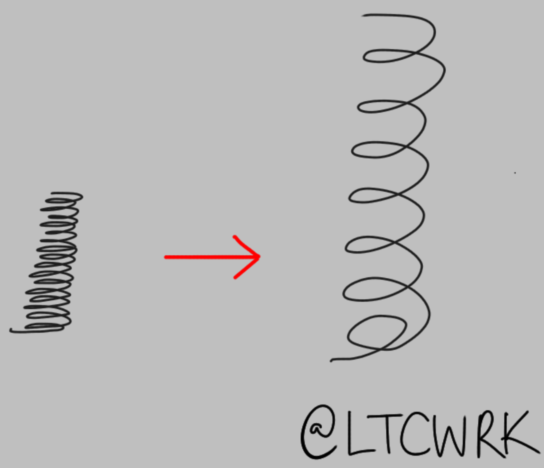
Swing is extreme coordination. It's a maintaining balance, equilibrium. It's about executing very difficult rhythms with a panache and a feeling in the context of very strict time. So, everything about the swing is about some guideline and some grid and the elegant way that you negotiate your way through that grid.

– *Wynton Marsalis*

Hysteresis

Hysteresis is when the state of a system is dependent on its history – what happened previously influences what happens next.

It can also be thought of as delayed feedback, where a result lags behind that which causes it. Another word for this is springloading, and every human system is either positively or negatively springloaded. Understanding this may help clarify why certain situations unfold the way they do, such as the "powder keg" that was Europe before WWI.



One basic principle found throughout nature is this: tension seeks resolution. From the spider web to the human body, from the formation of galaxies to the shifts of continents, from the swing of pendulums to the movement of wind-up toys, tension resolution systems are in play. We can observe in nature and in our lives both simple and complex tension-resolution systems that influence not only the changes that occur but how those changes will occur. The simplest tension-resolution system is a structure that contains a single tension. The tendency of the structure is to resolve the tension. If you stretch a rubber band, the tendency of the rubber band is to pull back to resolve the tension in the structure. A compressed coiled spring has a tendency to release the tension by springing back toward its original state.

– Robert Fritz, The Path of Least Resistance

As the African proverb goes, “If you want to go fast, go alone. If you want to go far, go together.”

Thank you for choosing to go together.