

# **The Meaning of Time**

*A Theory of Nothing*

Gene T. Yerger

HANOVER BOOKS  
NEW HANOVER  
PENNSYLVANIA

---

---

# Contents

---

---

Dedication .....	vii
Acknowledgements .....	ix
Preface .....	xiii

## **Part One: The Anthropic Universe**

I Perspective .....	3
II Belief .....	10
III Einstein's Unfinished Revolution .....	28

## **Part Two: The Spacetime Continuum**

IV In the Beginning... ..	51
V The Essence of Time .....	84
VI Space (and) Time .....	109
VII Circles in the Present Tense .....	132
VIII The Arrow of Time .....	162

## **Part Three: The Quest For Quantum Reality**

IX Nothing is Real .....	181
X Schrödinger's Cat and the EPR Paradox .....	202
XI Quantum Blackjack .....	225
XII Looking For Mr. Higgs .....	243
XIII The Cosmic Code .....	272

## **Part Four: The Final Frontier**

XIV The Theory of Nothing .....	299
XV The Mind of God .....	322
Index .....	335

---

---

# Preface

---

---

*No, you're not thinking; you're just being logical.*

*Niels Bohr to Albert Einstein*

*He utters his opinions like one perpetually groping, and never like one who believes he is in possession of definite truth.*

*Albert Einstein on Niels Bohr*

There is a hole at the heart of physics.

The hole is characterized by a schizophrenic disorder, which has stymied the search for the Holy Grail of science. The dream of physicists is to combine the four known forces of nature—gravity, electromagnetism, and the strong and weak nuclear forces—into one fundamental interaction: a unified *theory of everything*. At the core of this crisis—in this author's view—is our inability to solve the enigma of time. This problem will remain unresolved, until we are able to answer the question “What is time?” At present, *there is not even one research program* focused on this subject and in this book, I propose an answer to this question.

So why is this a problem?

This brings us to the schizophrenic part. Most of the science that has been developed over the last one hundred plus years is represented by just two theories: Albert Einstein's general theory of relativity and quantum mechanics as originally developed under the auspices of Einstein's contemporary philosophical adversary, Niels Bohr. General relativity is

our most successful theory of gravity, and describes motion on planetary to cosmological scales. Quantum theory, on the other hand, deals with motion on the microscopic scale of electrons and protons. But this correspondence is the limit of their similarity.

The general theory of relativity is deterministic, as is classical Newtonian physics. In other words, every physical event in general relativity is causally determined by an unbroken series of prior events; this idea is also at the core of classical mechanics. Until the 1920s, it was widely held that all natural laws shared the determinism of classical mechanics. Quantum theory, on the other hand, is the antithesis of Newton's deterministic classical mechanics. In the murky quantum realm, uncertainty and indeterminism reign. Quantum physics can only provide the *probability* that an elementary particle (an electron, for example) will be found within a certain volume of space. More importantly, this indeterminacy does not arise from a lack of adequate information about the physical situation, but instead is a *fundamental feature of the theory*. Einstein, for one, never accepted that this interpretation could reflect the fundamental physical world. As a result, he and Bohr sustained a long-running public discourse over the proper interpretation of quantum theory—a theatre of the sublime, acted out on the world stage for the highest of stakes: our understanding of reality itself.

One of the most widely recognized symptoms of this personality disorder is the manner in which each theory describes gravity. In general relativity, the gravitational force is considered to be a consequence of the *geometry of spacetime*; matter and energy induce a curvature in the coordinates themselves, so that the shortest path between two points is no longer a straight line. This phenomenon is analogous to the way in which airplanes fly along curved trajectories—on a spherical surface, the shortest path between two points is always along the largest possible circumference connecting them. Because general relativity is usually applied to large-scale structures, however, the uncertainty and indeterminism inherent to quantum mechanics—anathema to Einstein's geometric approach—can easily be ignored.

In the quantum realm, the accepted theory of fundamental particles and forces is the Standard Model. In the Standard Model, interactions between subatomic particles such as electrons, protons, and quarks are always represented by the exchange of bosons, which are a separate category of force-carrying particles. Photons, for example, are the bosons that transmit the electromagnetic force. Because the idea of representing forces as particles works so well for electromagnetism, as well as for the strong and weak nuclear forces, it is theorized that the gravitational force should also be mediated by the exchange of bosons known as *gravitons*. The hypothetical graviton has yet to be detected, but there are difficult

technical issues that make this unlikely for the moment. Thanks to the extreme weakness of gravity, however, the Standard Model can fully embrace quantum uncertainty and successfully treat the other three forces while completely ignoring gravity.

So quantum mechanics is insignificant on the scales where gravity is strong, and gravity is insignificant on scales where the other forces are most important. In this manner each theory remains insulated from the other, and the two are thereby able to maintain a peaceful coexistence. So far, physicists have been unable to reconcile the quantum mechanical view and the general relativistic view; a consistent and testable theory of *quantum gravity* remains beyond their reach. This is the source of the aforementioned personality disorder, which has plagued the physics community and blocked progress in the search for an all-encompassing theory.

A critical symptom of this inconsistency can be found in each theory's treatment of time, where important differences have not been adequately acknowledged. In this author's view, this dissimilarity has been the *ultimate* source of physics' inability to solve this crisis. The scientific community, however, seems conflicted about time's true role in the physical world. There is a certain ambivalence among physicists regarding the problem of time in both relativity theory and quantum theory.

In general relativity, measurements of time and distance (spacetime) are in the *foreground*, and these measurements are warped and deformed by the presence of massive bodies such as the Sun and the Earth. In general relativity time is treated as a (fourth) dimension on equal footing with space, if slightly different. In reality, however, time in both special and general relativity is a mathematical abstraction that, as I will demonstrate, simply quantifies the correct causal structure of the universe. Within this causal framework, the notions of past, present and future as we intuitively understand them are no longer absolute but are assigned to each spacetime point and thereby deny the uniqueness of *anyone's* time. The twin theories also posit that motion and the effects of a gravitational field slow time but then leave time itself undefined.

In quantum theory, time resides quietly in the background and reliably preserves the pace of physical processes. In quantum theory time is treated as a simple duration that evolves in the context of a flat, unchanging *background* known as Minkowski spacetime. In one of the most speculative iterations of quantum theory, however, something unexpected happens. In an equation that describes the quantum evolution of the universe and holds the promise of unifying general relativity and quantum theory, time simply disappears from the equation. This has led some to speculate that any final theory of everything will be timeless.

So what is the solution?

In **The Meaning of Time**—*A Theory of Nothing*, I will examine time in an unusual but not wholly unprecedented fashion. In my approach, I shall ascribe a *dual role* to time. Specifically, I will demonstrate that *gravity* and *time* are intimately related, and that this relationship is the source of time's dual nature. In this model, the distinction between past, present and future as discrete dimensions—what I will logically refer to as *dimension time*—is manifest. At the quantum level, however, I will introduce a physical process—what I refer in as *duration time*—that is akin to an internal clock inherent in all massive objects. The distinction between dimension time and duration time (as opposed to *coordinate time* in special and general relativity) lies at the heart of *the theory of nothing*, and will form the basis of a consistent quantum theory of gravity. The most salient point that will be scrutinized, however, is how dimension time and duration time are interconnected. Discovering the mechanism that controls this process, or equivalently providing an answer to the question “What is time?” is the primary objective of this book.

The search for a *theory of nothing* will be carried out on three levels. The first is personal. On this level a reborn intellect will grapple with the relationship between reality and consciousness, from the perspective provided by the radical innovations of quantum theory. This portion of the book will be an effort to gain insight into how our minds are related to the matter from which we are constituted. The context for this discussion will be provided in the first chapter, and each subsequent chapter will introduce its more substantive material with a personal perspective. In the last chapter, I will synthesize my personal perspective with *the theory of nothing* to create a physical approach towards the relationship between time, reality, and our consciousness of reality.

The second level of inquiry involves the metaphysical aspects of this journey. As will be indicated in the first chapter, my search for *the theory of nothing* began not as a search for a physical theory, but rather as a quest for spiritual connection with the universe and God. In pursuing a belief system, I discovered a disconnect between science and spirituality. In the second chapter, this tension between science and religion will be reviewed from a historical perspective. Early in each subsequent chapter, I will pose a provocative rhetorical question that will generally serve to illuminate the issues surrounding this subject. The final chapter is a highly speculative attempt to resolve the differences between science and spirituality within the context of *the theory of nothing*.

The final and most important level is that of physical theory, and in the third chapter I will introduce these issues and outline their scope. This book will cover quantum theory and the special and general theories of relativity in some considerable depth, the former primarily from the perspective of Bohr and Einstein's ongoing debate on the subject that lasted right up to Einstein's death in 1955. However, *the theory of nothing* will be based on my own unique interpretation of these theories. The theory will be presented in a largely non-mathematical fashion (with some exceptions), and within a historical context that will serve to compare and contrast our present state of knowledge about the universe with *the theory of nothing*. Simple examples will be used to explain complex topics, and these examples will be supplemented by graphics—figures, charts and diagrams—for reasons of both aesthetics and clarity. In the second section of the book the notion of time as a dimension will be discussed, and in the third section a similar treatment of quantum duration time will be presented. In the fourteenth chapter, all the concepts introduced over the course of the book will be synthesized into their final form—*the theory of nothing*.

As the curtain rises on this drama and the action begins, the story underlying *the theory of nothing* will unfold and the temporal duality that has now been introduced will be fully developed. From this analysis, I will draw fresh and startling conclusions about the nature of time: conclusions that will shed new light not only on the question of time but will also provide answers to even more fundamental questions of existence. In the end I will show that, in the final analysis, *the theory of nothing* might just well be—a *theory of everything*.

---

---

# Index

---

---

## A

absolutism, 111–113  
absorption lines, 188  
accelerated frame of reference, 39, 268  
accelerated motion, 37, 38, 111, 115,  
117–121, 128, 136, 137  
aces, 250  
action at a distance, 33, 37, 39, 40  
action principle, 218  
Adam and Eve, 332  
aether, 35, 37, 90, 91  
Agathon, 162  
Age of Enlightenment, 18, 19, 163  
Age of Reason, 18  
Anderson, Carl, 283  
anomalous Zeeman effect, 190–193  
anthropic landscape, 312, 313  
anthropic principle, 25, 26, 144, 312  
antimatter, 71, 259, 276, 277, 281, 282, 284  
Aristotle, 114, 116, 186  
arrow of time, 155, 156, 167–171,  
173–176, 269, 331  
biological, 169, 174, 175, 176, 331  
cosmological, 169, 174, 175, 331  
gravitational, 173, 175  
intellectual, 167–169, 174–176, 331  
metaphysical, 333  
psychological, 169, 174–176, 331  
thermodynamic, 156, 169–171, 174,  
175, 331  
Aspect, Alain, 213  
astronomy, 11, 15, 248  
asymptotic freedom, 258

## B

baryons, 249, 250, 258, 262,  
286, 307  
basic strategy, 227, 234–236, 239, 294  
Bell, John Stuart, 212

Bell's inequality, 212, 213  
Bell's theorem, 212, 217  
Berkeley, George, 113, 181  
beta decay, 259, 307  
Big Bang theory, 21, 33, 61–67, 69, 70,  
72, 74, 83, 149, 171–174, 302  
dark energy and, 69  
dark matter and, 68, 69  
flatness problem and, 63–65  
geometry of universe and, 64  
horizon problem and, 63  
Big Bang singularity, 62, 318  
Big Crunch, 61  
blackbody radiation, 41, 42, 61, 62, 187  
black hole, 12, 68, 77, 104, 105, 117,  
143–145, 149, 155, 156, 291,  
317, 318  
black hole event horizon, 143, 145, 149,  
156, 293  
blackjack, 225–242, 294  
basic strategy and, 227, 234–236, 295  
card counting and, 228–230, 232, 233, 295  
Bohr, Niels, xiii, xiv, 13, 22, 41, 43, 45,  
184, 185, 187–191, 194, 197–201,  
204, 208, 241, 243, 277, 278, 280,  
282, 294, 299, 300, 321  
Bohr-Einstein debate, xiv, 43, 45, 191,  
276, 299, 300, 321  
Bohr model and, 187–190, 278  
complementarity and, 184,  
198–200, 204  
Copenhagen interpretation and, 45,  
185, 241  
measurement problem and, 185, 198  
Bohr-Einstein debate, xiv, 43, 45, 46, 191,  
197, 276, 299, 300, 321  
Bohr model, 187–190, 192, 193, 205,  
270, 278  
Bohr radius, 310

- Boltzman, Ludwig, 171, 191  
 Bolyai, James, 134  
 Born, Max, 189, 191, 195–197, 205, 208, 216  
 Bose, Satyendra, 246  
 Bose-Einstein statistics, 191, 246, 281  
 bosons, xiv, 66, 245–248, 254, 255, 257, 261, 262, 269, 281, 309, 318, 319  
 Brahe, Tyco, 14  
 Breit, G., 284  
 Brown v. Board of Education, 5
- C**  
 Calabi-Yau manifolds, 312  
 capitalism, 165, 167  
 card counting, 228–230, 232, 233  
 Cartan, Elie, 254  
 Carter, Brandon, 25, 26  
 Cartesian dualism, 182  
 cause and effect, 47, 237, 238, 301  
 Cepheid variables, 59  
 charge conjugation, 259, 260  
 Churchill, Winston, 3  
 classical electron radius, 287, 293  
 classical mechanics, xiv, 17, 22, 41, 48, 115, 116, 122, 123, 157, 184, 187, 190, 205, 207, 215, 278  
 classical proton radius, 267  
 Clauser, John, 212  
 collapse of the wave function, 79, 200, 206, 208, 209, 211, 214, 215, 219–221, 223, 231, 235, 240, 241, 266, 275, 294, 306, 308, 321, 330  
 color, 76, 80–82, 157, 158, 257–259, 263, 265, 269, 305, 309, 310, 315  
 communism, 165  
 complementarity, 183–185, 198–200, 204, 209  
 complex conjugation, 206, 207, 217  
 complex number, 253  
 Compton, Arthur, 190  
 Compton effect, 190  
 Compton wavelength, 148, 283, 287, 291, 292  
 consciousness, xvi, 167, 182, 183, 329–333  
 conservation of angular momentum, 116, 253, 288  
 conservation of energy, 8, 72, 116, 170, 253  
 conservation of linear momentum, 116, 253  
 coordinate time, xvi, 126, 128, 137, 142, 285  
 Copenhagen interpretation, 45, 185, 198, 206, 208–211, 213–216, 219, 220, 275  
 Copernican principle, 25  
 Copernicus, Nicholas, 15, 25, 57, 58  
 correspondence principle, 187, 188  
 cosmic deflation, 76, 125, 146, 306, 315, 316  
 cosmic microwave background radiation, 60–63, 67, 69, 70, 76  
 cosmological constant, 27, 58, 66, 69, 303, 314, 315, 318  
 cosmological event horizon, 150, 159  
 cosmological natural selection, 143, 144, 145  
 cosmological principle, 62  
 cosmology, 10, 11, 12, 53, 56, 57, 60, 171, 173, 303, 314  
 CPT theorem, 259  
 Cramer, John, 215–217  
 creationism, 19  
 critical density, 61, 64, 136
- D**  
 Dalibard, J., 212  
 dark energy, 10, 12, 69, 70, 303, 314–317  
 dark matter, 10, 12, 68–70, 303, 314–317  
 Darwin, Charles, 19, 26  
 de Broglie, Louis, 190, 192, 205  
 de Broglie conjecture, 266, 283  
 de Broglie frequency, 266, 283, 291, 292  
 de Broglie period, 267, 283, 292  
 deism, ix, 18  
 de Maupertuis, Pierre-Louis Moreau, 208  
 Descartes, Rene, 182  
 designer universe, 48  
 determinism, xiv, 22, 43, 45, 46, 47, 48, 196, 201, 223, 224, 236–238, 294, 301, 305

- dimension time, xvi, xvii, 77, 90, 101,  
 128, 142, 161, 177, 209, 221, 265,  
 267, 269, 285, 293, 305, 311
- Dirac, Paul, 45, 73, 74, 189, 195, 196, 246,  
 270, 276–286, 300, 301
- Bohr-Einstein debate and, 45, 300, 301
- Dirac equation and, 278–284
- hole theory, 282
- spin and, 277, 279, 280, 288
- Dirac equation, 276, 277, 279–281, 283,  
 284, 285, 288, 293, 310, 321
- Dirac hole theory, 73
- Dirac matrices, 288
- Dirac sea, 73
- Doppler effect, 59
- dualism, 182, 184, 331
- Duchak, Marlene, vii, 143, 323, 324, 326,  
 327
- duration time, xvi, xvii, 81, 82, 90, 100,  
 103, 105, 128, 142, 148, 150, 158,  
 177, 221, 222, 223, 240, 263,  
 265–269, 285, 286, 290, 291, 293,  
 295, 306, 310, 311, 315
- E**
- Ehrenfest, Paul, 280
- Eightfold Way, 250
- Einstein, Albert, ix, x, xiii, xiv, 10, 13,  
 20–22, 24, 26–28, 30–33,  
 35–48, 53, 54, 58, 60, 62, 63, 65, 66,  
 69, 74, 75, 83, 90, 91, 103,  
 106–108, 111, 113, 116–121, 124,  
 126–128, 135, 142, 144, 146, 161,  
 186, 187, 189–191, 196–201, 204,  
 205, 209, 211, 213, 220, 223, 224,  
 225, 231, 236, 241, 246, 253, 268,  
 270, 271, 272, 277, 281, 299–302,  
 314, 315, 319–321, 329
- Bohr-Einstein debate and, xiv, 43, 45,  
 46, 191, 197, 276, 299, 300, 321
- cosmological constant and, 27, 58, 66,  
 69, 314, 315
- energy-mass relation and, 71–73
- EPR paradox and, 209–213
- general theory of relativity and, xiii,  
 xiv, 20, 21, 39, 40, 43, 54, 58, 60,  
 63, 75, 106, 113, 117, 118, 120, 121,  
 127, 135, 144, 321
- God and, 10, 26, 27, 28, 32, 48, 83
- Kaluza-Klein theory and, 44, 45
- photoelectric effect and, 204
- special theory of relativity and, 20,  
 36–38, 43, 58, 75, 91, 106–108,  
 113, 116, 118, 119, 126, 146,  
 211, 329
- unified field theory and, 44, 45, 321
- Einstein equivalence principle, 120, 128
- Einstein field equations, 55, 62,  
 122, 319
- electric charge, 251, 256, 258, 260,  
 263, 282
- electromagnetic field, 122, 123, 157,  
 253–256, 258, 261, 311
- electromagnetic radiation, 34, 35, 38, 42,  
 68, 90, 91, 187, 188
- gamma rays, 34
- infrared, 34, 68
- microwave, 34
- radio waves, 34
- ultraviolet, 34
- visible light, 34, 91
- x-rays, 34, 68
- electromagnetism, 33, 34, 215, 253, 254,  
 261, 264
- electron, xiv, 42, 44–46, 54, 62, 65, 73,  
 74, 79, 80, 104, 123, 150, 157,  
 184–188, 190–194, 196, 197, 205,  
 206, 210, 214, 216–219, 222,  
 245–250, 255, 256, 258, 259, 261,  
 262, 268–270, 274–294, 302,  
 306–311, 314, 317
- electron degeneracy pressure, 317
- electron field, 157, 290, 307, 308
- electron quantum of time, 287, 292
- electroweak interaction, 66, 260–262,  
 305, 306, 315
- elliptic geometry, 134, 136
- emission lines, 188
- energy gap, 106, 291, 306
- Engels, Frederick, 163
- entanglement, 210, 215, 221, 265
- entropy, 156, 170–174
- epistemology, 300
- EPR paradox, 210, 211–213
- equilibrium theory, 166, 167
- equivalence principle, 16, 129, 130, 294

- Euclid, 134–136  
 Euclidean geometry, 64, 134–136  
 exchange force, 123, 245, 247, 248
- F**
- false vacuum, 66  
 Faraday, Michael, 32, 34  
 Faraday's law, 32, 33  
 fecund universes theory, 143, 144  
 Fermi, Enrico, 246, 259, 261  
 Fermi-Dirac statistics, 191, 246, 281  
 fermions, 79–81, 246–248, 255, 263, 281, 285, 318, 319  
 Feynman, Richard, 215, 217, 218, 222, 255  
 Feynman diagrams, 255, 256, 294  
 field, 33, 122–124, 157, 158, 254, 264  
 fine structure constant, 191, 192, 267, 292  
 fine-tuned universe, 56, 143  
 fine tuning problem, 69, 246, 303, 314, 315, 318  
 first law of thermodynamics, 170  
 first principles, 301, 303, 313, 320  
 flatness problem, 65, 67  
 Foldy-Wouthuysen transformation, 284, 285  
 Freedman, Stuart, 212  
 free will, 331–333  
 fundamental forces, xiii, xiv, 33, 37, 38, 44, 54, 55, 65, 66, 73, 113, 119–121, 123–126, 135, 143, 145–147, 150, 152, 154, 157–159, 245–248, 250, 252, 256, 257, 260, 261, 286, 290, 304, 306, 307, 309, 315, 318  
 electromagnetic force, xiii, xiv, 33, 44, 55, 65, 66, 73, 124, 125, 245–248, 252, 268, 270, 286, 290, 304, 306, 309, 315  
 gravitational force, xiii, 33, 37, 38, 44, 54, 55, 73, 113, 119–121, 123–126, 135, 143, 157, 159, 160, 286, 304, 307, 318  
 strong nuclear force, xiii, xiv, 44, 65, 73, 157, 245–248, 250, 252, 257, 259–261, 304, 305, 309, 315  
 weak nuclear force, xiii, xiv, 44, 65, 66, 73, 157, 245, 246, 248, 250, 252, 257, 259–261, 304, 305, 309, 315, 318
- fundamental gravitational force, 125, 158, 174, 269, 304, 305, 309, 315, 318  
 fundamental nuclear force, 245–248  
 future dimensions, 77, 143, 145–147, 150, 152, 154, 158, 159, 240, 301, 305, 312, 320, 329–331
- G**
- Galilean relativity, 34, 35, 91  
 Galilean transformation equations, 36, 90, 91, 98  
 Galilei, Galileo, 13–17, 20, 22, 32, 39, 57, 58, 90, 91, 114–116, 119  
 garden hose universe, 44, 55  
 Garden of Eden, 19, 332  
 gauge theory, 123, 157, 252–259, 261, 264, 265, 269, 308, 311, 328  
 gauge boson, 123, 124, 157, 158, 265, 269, 311  
 gauge field, 254, 255, 265, 269, 311  
 gauge particle, 265, 269, 311  
 gauge symmetry, 252, 253, 256, 258, 264, 328  
 gauge transformation, 253, 257, 261, 264, 265, 308, 311  
 Gauss, Carl Frederick, 134, 135  
 Geiger, Hans, 186  
 Gell-Mann, Murray, 250  
 general theory of relativity, xiii–xvii, 20, 37, 40, 43, 45, 53–56, 58, 60, 63, 70, 71, 77, 78, 82, 89, 104, 113, 117, 122, 124, 126, 129, 131, 135, 143, 144, 146, 149, 155, 161, 173, 176, 177, 253, 268, 285, 313, 314, 321  
 conflict with quantum mechanics, xiii–xv, 89, 122, 124, 131, 149, 155  
 cosmological constant and, 27, 58  
 Einstein equivalence principle and, 39, 40  
 Einstein field equations and, 40, 55, 319  
 geodesics, 127, 135  
 geometry of the universe, 63–65, 69, 135, 136, 159  
 closed/positive curvature, 63–65, 135, 136

- flat/zero curvature, 64, 65, 69, 135, 136, 159  
 open/negative curvature, 64, 65, 136  
 glueballs, 258  
 gluons, 158, 246–248, 257, 258  
 God, ix, xvi, 8–13, 17–19, 21, 26, 57, 83, 176, 209, 241, 322, 324, 327, 332, 333, 334  
 Gordon, W., 279  
 Gordon decomposition, 293  
 Goudsmit, Samuel, 193, 280  
 grand unified theories (GUTs), 65, 66  
 gravitational arrow of time, 173, 175  
 gravitational constant, 75, 116, 122, 149, 192  
 gravitational field, 72, 101, 104, 119, 120, 124, 127, 254, 318  
 gravitational mass, 16, 39, 116, 129, 131, 135, 143, 144, 149, 155, 158, 265, 267, 294, 307, 314, 315, 319, 321  
 gravitational singularity, 61, 70, 106, 149, 305  
 gravitons, xiv, 54, 124–126, 128, 155, 158, 222, 247, 248, 304, 309, 315, 318, 333  
 gravity, xiv, xv, 31, 39, 40, 53, 58, 65, 68, 71, 74, 101, 113, 114, 116, 119, 120, 121, 123–125, 128, 135, 143, 144, 149, 155, 158, 245, 248, 264, 270, 314, 316, 317, 329  
 Grossman, Marcel, 31  
 group theory, 253, 254  
 Guth, Alan, 66, 260, 261  
 gyromagnetic ratio, 270
- H**
- hadrons, 249–251, 259  
 half dimensions, 77, 151, 152, 153, 154, 155, 157  
 Hall, David B., 99  
 Hamilton, Sir William Rowan, 218  
 Hamiltonian mechanics, 218  
 Harpel, Pastor George, 324–327  
 Hartle, James, 219, 222  
 Hawking, Stephen, 219, 222  
 heat death, 156, 174  
 Heinz, Heinrich, 34  
 Heisenberg Werner, 22, 43, 46, 71, 185, 189, 194–198, 217, 218, 277, 278, 313  
 uncertainty principle and, 22, 46, 71, 196, 278, 313  
 hidden variables, 209, 210, 212, 213, 220, 223, 224, 238  
 hierarchy problem, 246, 303, 318, 319  
 Higgs boson, 104, 260, 260–262, 270, 318, 319  
 Higgs field, 104, 105, 260–262, 291, 318, 319  
 Higgs mechanism, 260, 261, 319  
 Hilbert, David, 31  
 Hilbert space, 205  
 holographic principle, 155, 156, 264, 330  
 Holt, Richard, 212  
 horizon problem, 63, 67  
 Horne, Michael, 212  
 Hubble, Edwin, 58–62  
 Hubble's law, 60, 69  
*Hubble Space Telescope*, 11, 12, 63  
 hydrogen atom, 62, 172, 188, 279, 286, 295, 301, 309–314  
 hyperbolic geometry, 134, 136, 150  
 hyperboloid of two sheets, 150–154, 158
- I**
- imaginary numbers, 137–139  
 imaginary time coordinate, 139  
 indeterminism, xiv, 22, 43, 45–47, 209, 300  
 inertia, 101, 104, 130  
 inertial frame of reference, 20, 37, 39, 91, 94, 96, 100, 102, 108, 119, 129, 268  
 inertial mass, 16, 39, 90, 105, 116, 128, 129, 131, 137, 157, 159, 160, 216, 238, 265, 267, 293, 307, 314, 315, 319, 320  
 inertial (uniform) motion, 90, 111, 113, 117–121  
 inflation, 21, 66, 67, 68  
 inflationary universe, 65–70, 260, 261  
 initial conditions, 70, 71, 73, 74, 77, 83, 125, 173, 302, 303, 309  
 intelligent design, 19, 57  
 invariant mass, 102, 103, 292

**J**

Jefferson, Thomas, 163  
 Johnson, Lyndon, 165, 168  
 Jordan, Pascual, 173, 195

**K**

Kaluza, Theodor, 44  
 Kaluza-Klein theory, 44, 55, 286, 308  
 Kant, Emmanuel, 199  
 Kennedy, John F., 4–6, 9, 89, 133,  
 162, 322  
 Kennedy, Robert, 5, 6  
 Kepler, Johannes, 14–16, 115  
 kinetic energy, 71, 72, 283, 292  
 King, Martin Luther, 5  
 Klein, Oskar, 44, 279  
 Klein-Gordon equation, 279  
 Kronig, Ralph, 280

**L**

Lande, Alfred, 192  
 LaPlace, Pierre-Simon, 18, 21, 22  
 law of inertia, 15, 90, 115  
 Leibniz, Gottfried, 8, 9, 22, 82, 111,  
 112, 130  
 length contraction, 92, 96–100, 106  
 leptons, 157, 248–250, 262, 286, 306,  
 307, 311  
 liberalism, 162, 165–166  
 libertarianism, 165  
 Lie, Sophus, 254  
 Lie algebra, 254  
 Lie groups, 254  
 life force, 333  
 light cone, 140, 141, 142, 146, 148  
 light-like interval, 140, 142, 143, 145,  
 147, 148, 152  
 Lobachevsky, Nikolai Ivanovich, 134  
 local phase angle invariance, 253, 256  
 local reality, 209, 212, 213  
 Locke, John, 163–165  
 logic, 29, 30, 48, 241  
   deductive, 30, 31, 241  
   inductive, 30, 241  
 Lorentz, Hendrik, 91, 186, 208, 278  
 Lorentz transformation equations, 36,  
 98, 101  
 Lucretius, 3  
 Luther, Martin, 17, 324

**M**

Mach, Ernest, 113, 198  
 Mach's principle, 113  
 magnetic moment, 193, 194, 256, 279,  
 280, 283  
 magnetic monopoles, 65, 66  
 Marsden, Ernest, 186  
 Marx, Karl, 163  
 mass, 54, 68, 71, 75, 101–105, 108,  
 116, 117, 123, 128, 130, 143, 148,  
 149, 155–157, 194, 238, 247,  
 249–251, 256, 260, 261, 264, 265,  
 267, 283, 285, 291, 306–308, 314,  
 316, 319  
 mass-energy, 71–73, 136  
 matrix mechanics, 195, 196, 217, 247,  
 277–279  
 matter waves, 184, 185, 196  
 Maxwell, James Clerk, 33–37, 41,  
 91, 215  
 Maxwell's equations, 34, 35, 41, 45, 91,  
 122, 123, 186, 216, 256  
 measurement problem, 185, 198, 199,  
 206, 241, 275, 291  
 Mendeleev, Dmitri, 188  
 mesons, 247, 249, 250, 258, 259  
 Michelson, Abraham, 35  
 Milky Way, 11, 12  
 Millikan, Robert, 282  
 Mills, Robert, 254  
 Minkowski, Hermann, 99, 137  
 Minkowski spacetime, xv, 98, 126,  
 127, 137, 139, 142, 143, 147, 148,  
 155, 320  
 monism, 182  
 Morley, Edward, 35  
 motion through time, 76, 77, 79, 90, 92,  
 98, 101, 103, 104, 106, 108, 128,  
 129, 131, 137, 145–153, 155, 156,  
 160, 174, 176, 222, 263, 265, 267,  
 268, 285, 286, 292, 307, 308, 312,  
 314, 315, 319–321, 330  
 muon, 99–101, 249, 250, 306

**N**  
 Napoleon, 18  
 Nash, John, 166, 167  
 natural selection, 19, 23, 144  
 Ne'eman, Yuval, 250

- negative energy particles, 74–77,  
79–82, 105, 106, 125, 126, 128–130,  
137, 143, 145, 146, 148–152,  
155–159, 174, 217, 221–223, 238,  
240, 262–266, 268, 269, 286, 291,  
295, 304–307, 309, 312, 314, 315,  
317–319, 321, 329, 330, 333
- negative energy state, 73–76, 82, 125,  
216, 220, 281–283, 285, 286, 288,  
290, 291, 293, 307, 308, 310,  
314, 316
- net nothing, 72, 125, 145, 159, 223, 304,  
309, 316, 332
- neutrino, 248–250, 259, 260, 262, 286
- neutron, 62, 77, 79, 81, 128, 157, 158,  
172, 193, 222, 245, 247, 249,  
257–259, 262, 263, 266, 286,  
295, 305, 307, 308, 313, 315,  
317, 318
- neutron degeneracy pressure, 318
- neutron stars, 56, 124, 317
- Newton, Isaac, 8, 13, 17, 18, 20–22, 24,  
32, 33, 37, 38, 41, 58, 90, 108,  
111–113, 115–117, 121, 128, 130,  
218, 252, 281, 328
- Newtonian mechanics, xiv, 34–37, 39,  
45, 47, 71, 92, 99, 103, 116,  
191, 241
- Newton's law of gravitation, 33, 37–40,  
115–117, 121–123, 186
- Newton's laws, 90, 103, 115, 122, 186,  
218, 328
- Newton-Wigner representation, 284
- Nixon, Richard, 162
- Noether's theorem, 328
- non-commuting variables, 195, 210, 211
- nothing, 3, 4, 8, 9, 185, 186,  
199, 208
- nucleosynthesis, 62
- O**
- objective reality, 209, 210, 212, 213
- observer created reality, 207, 208, 210,  
214, 215, 271, 275, 330
- Ockham, William of, 222
- Ockham's razor, 15, 222, 312, 319
- omega, 64, 136, 144
- ontology, 300
- oscillating universe theory, 61
- P**
- parallel postulate, 134–136
- parity reversal, 259, 260
- Pascal, Blaise, 132
- past dimensions, 77
- path integral, 218, 255
- Pauli, Wolfgang, 189, 192, 195, 197, 247,  
259, 278, 280
- Pauli-Dirac representation, 284, 286
- Pauli exclusion principle, 73, 79–82, 158,  
192, 193, 247–249, 257, 263, 281,  
282, 309, 317
- Penzias, Arno, 61
- periodic table of elements, 188, 247, 249,  
281, 311, 314
- perturbation theory, 255, 256
- philosophy of mind, 182, 183, 328
- photoelectric effect, 42, 43, 187,  
189, 204
- photon, xiv, 42, 43, 66, 103, 104,  
123–125, 157, 158, 190, 212, 213,  
222, 246–248, 255, 258, 261, 262,  
281, 289, 290, 309, 311
- Planck, Max, 41, 107, 186–188
- Planck's constant, 42, 75, 149, 192, 193,  
195, 306
- Planck units, 54, 70, 105, 148, 149, 152,  
267, 318
- Planck energy, 70
- Planck length, 54, 105, 149
- Planck mass, 105, 148, 152, 153, 318
- Planck time, 105, 148, 152, 153, 267
- Podolsky, Boris P., 209
- positive energy particle, 76, 77, 79–82,  
105, 106, 125, 126, 128–130, 137,  
142, 143, 145, 146, 148–152,  
155–159, 174, 217, 221–223, 238,  
240, 262–266, 268, 269, 286, 291,  
295, 304–306, 309, 312, 314, 315,  
317–319, 321, 329, 330, 333
- positive energy state, 74–76, 82, 125, 173,  
216, 220, 281, 283, 285–287, 290,  
291, 293, 304, 307, 308, 310, 314,  
316
- positron, 123, 259, 282
- potential energy, 71, 72, 74, 76, 254  
gravitational, 71, 72, 74, 254
- principle of least action, 218
- principle of stationary action, 218

- principle of sufficient reason, 8, 82
  - probabilities in quantum mechanics, xiv, 46, 48, 184, 185, 191, 198, 199, 201, 205–209, 214, 216, 223, 235, 237, 240–242, 253, 275
  - probability amplitude, 205–208, 221, 238, 292
  - probability current, 292
  - probability density, 279, 292, 293, 310, 311
  - proper length, 96–98
  - proper time, 94–96
  - proton, xiv, 62, 65, 77, 79, 81, 123, 128, 145, 148, 150, 157–159, 172, 184, 188, 193, 217, 222, 245, 247, 249, 257–259, 262–265, 267–269, 282, 286, 287, 292, 294, 302, 305–313, 315, 317, 333
  - proton decay, 65
  - proton quantum of time, 267
  - proto-particle, 74–76, 304, 307, 315
  - proto-universe, 73–76, 145, 149, 159, 173, 282, 303, 306, 316, 334
  - Ptolemaeus, Claudius, 14
  - Ptolemaic system, 14, 15
  - Pythagorean theorem, 137
- Q**
- QCD, 257
  - QED, 255–257, 269, 270
  - quanta, 42, 80, 123, 189, 205, 224
  - quantum algebra, 195, 276
  - quantum blackjack, 224, 225, 230, 233–242, 293–295
  - quantum chromodynamics (QCD), 81, 158, 257–259, 262
  - quantum cosmology, 65, 218, 219
  - quantum electrodynamics (QED), 123, 124, 158, 255, 256
  - quantum field theory, 73, 81, 123, 124, 148, 155, 157, 254–257, 264, 265, 270, 314, 315
  - quantum gravity, 124, 125, 155–159, 177, 219, 248
  - quantum mechanical interpretations, 185, 198, 205, 206, 208–211, 213–215, 216–220, 241, 275, 286
    - Copenhagen interpretation, 185, 198, 206, 208–211, 213–215, 216, 219, 220, 241, 275
    - local hidden variables, 210, 212, 213, 220
    - non-local hidden variables, 210, 213, 217, 224
    - sum over histories, 217–221, 223
    - transactional interpretation, 215, 217, 220, 221, 286
    - wave function of the universe, 218
  - quantum mechanics, xiii, xiv, xv, 22, 32, 43, 45, 47, 48, 73, 89, 122–124, 143, 149, 150, 155, 157, 176, 184–186, 189–191, 194–200, 203, 205–207, 209–211, 215–218, 220, 224, 235, 236, 241, 242, 247, 253, 255, 270, 274, 277–279, 282, 294, 300, 303, 321
    - complementarity and, 184, 185
    - conflict with general relativity, xiii–xv, 89, 122, 124, 131, 143, 149, 155
    - entanglement and, 215
    - superposition principle and, 207, 208, 215
    - wave-particle duality and, 184, 185
  - quantum number, 76, 80, 188, 191, 192, 193, 246, 247, 250
  - quantum of time, 105, 149, 267, 292
  - quantum statistics, 43, 191, 246, 280
  - quantum theory, xiv–xvi, 27, 41–43, 45, 46, 48, 53, 56, 69, 71, 78, 79, 82, 131, 143, 149, 155, 173, 176, 183–185, 188, 189, 198, 215, 218, 220, 223, 224, 242, 270, 278, 281, 284, 294, 299, 300, 313, 321, 330
  - quantum tunneling, 66
  - quark, xiv, 54, 81, 82, 104, 157, 245–247, 249–251, 257–259, 262, 264, 302, 306, 309, 311
  - quark confinement, 258, 259
  - quark flavors, 250, 251, 306
    - bottom, 251, 306
    - charm, 251, 306
    - down, 250, 251, 259, 306
    - strange, 250, 251, 306
    - top, 251, 306
    - up, 250, 251, 259, 306
  - quark-gluon plasma, 62
  - quark model, 250, 264

**R**

radiation resistance, 216  
 Rayleigh, Lord, 186  
 Reagan, Ronald, 165  
 recombination, 62, 63, 66  
 relationism, 111–113, 130  
 relativistic mass, 101, 102  
 relativity of simultaneity, 92–94, 98  
 relativity principle, 35, 39  
 renormalization, 255–257, 270  
 residual gravitational force, 125, 127, 145,  
 159, 174, 268, 307, 309, 316  
 residual nuclear force, 245, 246, 248  
 rest energy, 77, 102, 128, 281, 282  
 rest mass, 101  
 retro-causation, 47, 217, 223, 238, 239,  
 266, 301, 306  
 retrograde motion, 14  
 Riemann, Bernhard, 134–136  
 Roger, G., 212  
 Roman Catholic Church, 14  
 Roosevelt, Franklin Delano, 165, 168  
 Rosen, Nathan, 209  
 Rossi, Bruno, 99  
 Rutherford, Ernest, 186, 187, 259, 278

**S**

Schrödinger, Erwin, 189, 196, 197, 202,  
 205, 209, 214, 215, 217, 231, 270,  
 275–279, 283  
 Schrödinger equation, 196, 197, 205, 208,  
 209, 214, 216–220, 275, 276, 278,  
 280  
 Schrödinger's cat, 209, 214, 215, 219,  
 231, 235  
 Schwarzschild radius, 148, 149  
 Schwinger, Julian, 255  
 scientific method, 13, 17, 20, 23, 24  
 second law of thermodynamics, 156, 170,  
 172, 173, 175, 176  
 September 11, 2001, 3, 4, 6, 7, 9, 10, 89,  
 322, 324  
 Shakespeare, William, 181  
 Shimony, Abner, 212, 213  
 singularity, 21, 74, 105, 143–145, 149, 150,  
 318  
 Smith, Adam, 164, 165  
 Smolin, Lee, 144  
 socialism, 165, 167

Sommerfeld, Arnold, 191, 192  
 space-like interval, 139, 142, 146–148  
 spacetime, xiv, 40, 44, 45, 55, 57, 58, 70,  
 74, 77, 91, 98, 101, 105, 106, 113,  
 121–131, 135–140, 142, 145–152,  
 155, 156, 160, 161, 173, 174, 224,  
 264, 268, 286, 287, 289, 292, 307,  
 312, 314, 317, 319, 329, 333  
 spacetime interval, 137–141, 148, 151,  
 155, 267  
 special theory of relativity, xv–xvii, 31,  
 36–40, 43, 45, 53, 71, 77, 78, 82,  
 91–104, 107, 108, 111, 113, 116,  
 118, 123, 126, 131, 137–140, 143,  
 146–148, 187, 208, 211, 213, 268,  
 276–279, 282, 285, 293, 303, 313,  
 320, 329  
 length contraction and, 92, 96–100  
 Minkowski spacetime and, 98, 99, 126,  
 142, 147, 320, 329  
 motion through time and, 98, 268  
 relativity of simultaneity and, 92–94, 98  
 time dilation and, 92–96, 98–101, 267,  
 292  
 spectral lines, 59–61, 68, 188  
 absorption lines, 188  
 blue shift, 60  
 emission lines, 188  
 red shift, 60, 61, 68  
 speed of light, 31, 34, 37, 38, 91–98, 100,  
 102–105, 107, 108, 116, 117, 126,  
 137, 140–142, 147, 149, 150, 152,  
 192, 194, 222, 224, 247, 268, 281,  
 283–287, 292, 293, 306, 307, 310,  
 330  
 Maxwell's theory and, 34, 91  
 Minkowski spacetime and, 98, 126, 137  
 motion through time and, 105, 147,  
 152, 222, 224, 268, 286, 307,  
 310, 330  
 special relativity and, 91, 93, 98  
 universal constant and, 31, 37, 38, 91,  
 98, 100, 102, 103, 107, 117, 126,  
 192, 194, 292  
 Spencer, Herbert, 19  
 spin, 54, 74, 76, 80–82, 157, 158, 193,  
 194, 208, 247–251, 260, 263–266,  
 268, 269, 276–283, 285–291, 293,  
 295, 304–308, 310, 321

- spinor, 278, 280  
 Spinoza, Baruch, ix  
 spin statistics theorem, 246  
 spontaneous symmetry breaking, 66, 261  
 Spring Mount, 51, 52, 132, 272, 273  
 Standard Model, xiv, xv, 53, 65, 71,  
     104, 124, 126, 245, 247, 248,  
     251–254, 257, 261, 262,  
     269–271, 285, 286, 291, 312,  
     318, 319  
 state vector, 206, 208, 210, 211  
 statistical mechanics, 191, 223, 280  
 steady state theory, 60, 61  
 Stevenson, Adali, 322  
 strangeness, 250  
 strings, 54, 56, 77, 105, 128, 145,  
     221, 265, 269, 291, 293, 306, 308,  
     312, 330  
 string theory, 54–56, 70, 126, 270, 271,  
     312, 313  
 substance dualism, 182  
 substantivalism, 111, 112  
 superposition principle, 207, 208, 209, 235  
 supersymmetry, 318–320  
 Susskind, Leonard, 155, 156, 312  
 symmetry, 246, 250, 252–255, 257, 259,  
     261–264, 319, 328, 331, 334
- T**  
 tauon, 249, 306  
 temporal degeneracy pressure, 318  
 temporal event horizon, 44, 79, 126, 143,  
     145, 146, 148–150, 152, 157, 158,  
     221, 222, 239, 263, 265–269, 286,  
     287, 292, 293, 304, 306, 307, 310,  
     315, 317  
 temporal gauge invariance, 265, 269,  
     308, 311  
 temporal geometry of universe, 128, 146,  
     155, 159, 317  
 ten-dimensional spacetime, 44, 45, 55, 59,  
     160, 305, 312, 313, 320, 329  
 theory of everything, xvi, 33, 43, 48  
 theory of evolution, 19, 23, 57, 144  
 thermodynamics, 35  
*the theory of nothing*, xvi, xvii, 25, 43, 44,  
     46, 47, 56, 57, 70, 72–83, 90, 100,  
     101, 103, 105, 106, 108, 125–130,  
     136, 140, 142–161, 173, 174, 177,  
     181, 183, 201, 215, 217, 220–222,  
     224, 230, 237–242, 249, 260,  
     262–269, 275, 277, 284–295,  
     300–320, 322, 324, 328–331, 333, 334  
 accelerated frame of reference and,  
     125–130, 268  
 accelerated motion and, 128, 129  
 black holes and, 317  
 Bohr-Einstein debate, 300  
 cause and effect and, 238, 301  
 collapse of the wave function and,  
     220–223, 306, 308, 321, 330  
 color and, 76, 80, 81, 82, 157, 158, 263,  
     265, 269, 305, 309, 310, 315  
 consciousness and, xvi, 329–333  
 coordinate time and, xvi, 126, 128, 142  
 cosmic deflation and, 76, 146, 306,  
     315, 316  
 cosmological constant and, 303, 318, 319  
 cosmological event horizon, 150, 159  
 cosmological natural selection and,  
     143, 144  
 cosmology and, 314  
 dark energy and, 315–317  
 dark matter and, 315–317  
 determinism and, 294, 305  
 dimension time and, xvi, 77, 90, 91,  
     128, 142, 161, 177, 221, 265, 267,  
     269, 285, 293, 305, 311  
 Dirac sea and, 73  
 duration time and, xvi, 81, 82, 90,  
     100, 103, 105, 128, 143, 148, 150,  
     158, 177, 221–223, 240, 263,  
     265–269, 285, 286, 290, 291, 293,  
     295, 306, 310, 311, 315  
 Einstein equivalence principle and,  
     128–130  
 electron and, 268, 285, 286–292, 294,  
     306–311, 314  
 equivalence principle and, 129  
 fine-tuned universe and, 56, 57  
 first principles and, 47, 149, 301, 303,  
     313, 320  
 free will and, 331–333  
 fundamental gravitational force and,  
     125, 158, 174, 269, 304, 305, 309,  
     315, 318

- future and, 77, 105, 143, 145–147, 150, 152–154, 158, 159, 301, 305, 312, 320, 329–331, 333  
 gauge symmetry and, 264  
 general relativity and, 45, 77, 125, 129, 143, 146, 159  
 God and, xvi, 322, 324, 332–334  
 gravitational arrow of time and, 173–175  
 gravitational force and, 159, 160, 307  
 gravitational mass and, 129, 131, 137, 157, 267, 307, 315, 319, 321, 324  
 graviton and, 125, 126, 128, 158, 269, 304, 309, 315, 318, 333  
 half dimensions and, 151–155, 157  
 hidden variables and, 223, 224, 238–240  
 hierarchy problem and, 318  
 Higgs mechanism and, 319  
 holographic principle and, 155  
 hydrogen atom and, 286, 295, 301, 309–313  
 hyperboloids of two sheets and, 150–154, 158  
 inertial mass and, 105, 108, 129–131, 137, 157, 159, 160, 267, 307, 314, 315, 319, 320  
 initial conditions and, 72, 77, 83, 173, 302, 303, 309  
 Kaluza-Klein theory and, 286, 308  
 life force and, 333  
 mass and, 108, 128, 130, 148, 156, 157, 249, 264, 267, 284, 291, 292, 306–308, 314, 316  
 measurement problem and, 241, 291, 330  
 metaphysical arrow of time and, 333  
 mind and matter and, 181, 328  
 Minkowski spacetime and, 142, 143, 152, 320  
 motion through time and, 76, 77, 79, 90, 100, 101, 103–106, 108, 128–131, 137, 145–153, 155, 156, 160, 174, 222, 224, 263, 265, 267, 268, 284–286, 292, 307, 308, 310, 312–315, 319–321, 330  
 multiple dimensions and, 44, 47  
 negative energy particles and, 74–77, 79–82, 105, 106, 125, 126, 128–130, 137, 143, 145, 146, 148–152, 155–160, 174, 217, 222–223, 238, 240, 262–266, 268, 269, 286, 291, 295, 304–307, 309, 310, 312, 314, 315, 317–319, 321, 329, 330, 333  
 negative energy state and, 74–76, 82, 125, 285, 286, 288, 290, 291, 293, 303, 304, 307, 308, 310, 314, 316  
 net nothing and, 125, 145, 149, 173, 223, 304, 309, 316, 332  
 neutron and, 79, 81, 125, 128, 263, 266, 286, 295, 305, 307, 308, 313, 315, 317, 329  
 Pauli exclusion principle and, 79–82, 158, 309  
 positive energy particle and, 76, 77, 79–82, 105, 106, 125, 126, 128–130, 137, 142, 143, 145, 146, 148–152, 155–160, 174, 217, 221–223, 238, 240, 262–266, 268, 269, 286, 291, 295, 304–307, 309, 312, 314, 315, 317–319, 321, 329, 330, 333  
 positive energy state and, 75, 76, 82, 125, 145, 173, 285–287, 290, 291, 293  
 probabilities and, 46, 47  
 probability density and, 150, 222, 291, 310, 311  
 proton and, 79, 81, 128, 145, 148, 263–269, 286, 287, 292, 294, 305–311, 313, 315, 317, 329, 333  
 proto-particle and, 74–76, 304, 307, 315  
 proto-universe and, 73–76, 125, 145, 149, 159, 173, 303, 306, 316, 334  
 purposefulness of the laws of nature and, 47, 56, 143, 159, 237, 242, 300  
 quantum blackjack and, 294, 295  
 quantum chromodynamics and, 81, 82  
 quantum of time and, 105, 149, 267, 292  
 quantum theory of gravity and, 126, 143, 157–159  
 quark model and, 81, 82, 263, 264  
 reality and, xvi, 101, 330, 331

*the theory of nothing (continued)*

residual gravitational force and,  
125–127, 145, 159, 174, 268, 307,  
309, 316, 318

retro-causation and, 47, 217, 223, 238,  
239, 266, 301, 306

space particles and, 315, 316

spacetime and, 74, 77, 105, 125, 126,  
128–130, 145–147, 150–152, 155, 159,  
160, 264, 268, 288, 307, 312, 313, 317,  
319, 329

spacetime interval and, 146, 151,  
155, 267, 287

spacetime quantization and, 152,  
284, 288

special relativity and, 45, 77, 140, 142,  
143, 267, 320

spin and, 74, 76, 80–82, 125, 158,  
263–266, 268, 269, 285–291, 295,  
304–308, 310, 321

strings and, 77, 105, 128, 145, 221,  
265, 268, 269, 287, 291, 293, 306,  
308, 312, 330

string theory and, 56, 77, 312, 313

sum over histories and, 221, 223

superposition principle and, 222,  
223, 238

supersymmetry and, 318, 319, 320

temporal degeneracy pressure and, 318

temporal event horizon and, 44, 77, 79,  
126, 129, 143, 145, 146, 148, 150,  
152, 157, 158, 221, 222, 239, 263,  
265–269, 286, 287, 292, 293, 304,  
306, 307, 310, 315, 317

temporal gauge invariance and, 265,  
269, 308, 311

temporal geometry of universe and, 77,  
125, 146, 155, 159, 174, 305,  
317, 329

time and, 107, 128, 130, 137, 161, 241,  
267, 268, 285, 286, 291–293, 295,  
305, 329, 330, 334

transactional interpretation and, 220,  
221, 286

tri-color fields and, 264, 269, 309, 310,  
315–317

uncertainty principle and, 46, 47

universe and, 56, 57, 72

wave function of the universe and,  
222, 310

wave-particle duality and, 78, 266, 333

Zitterbewegung and, 286, 288, 291

Thompson, J.J., 186, 187, 277, 278

t'Hooft, Gerard, 155, 156

time, xiii, xv, xvi, 58, 73, 76, 77, 85–98,  
104–108, 110, 126–128, 130,  
136–138, 145, 147–153, 155, 156,  
160, 161, 167–171, 173, 176, 177,  
206, 220, 241, 263, 265, 267–269,  
271, 279, 284–286, 290–293, 295,  
305, 307, 308, 310–315, 319, 321,  
329–331, 334

arrow of time and, 155, 167–171, 173,  
269, 331

cause and effect and, 236–239

coordinate time and, xvi, 285

general theory of relativity and, xv, 89,  
127, 173

geometry and, 133, 160

language and, 88

motion in time and, 76, 77, 90, 92, 98,  
101, 103–105, 108, 128–131, 136,  
145, 146, 148–153, 155, 156, 160,  
263, 265, 267, 284–286, 292, 307,  
308, 310, 312–315, 319, 321

problem of time, xv, xvi, 88–90

proto-universe and, 73

quantum mechanics and, xv,  
89, 173

special theory of relativity and, 58, 91,  
92, 126, 138, 329

temporal geometry of the universe and,  
136, 159

*theory of nothing* and, 107, 128, 130,  
137, 241, 285, 286, 291–293, 295,  
305, 329, 330, 334

wave function of the universe  
and, 219

time dilation, 92–95, 98, 99, 101,  
268, 293

time-like interval, 140, 142, 148

time reversal, 260

Tomonga, Sin-itiro, 255

toy model, 147

transformation laws, 36

transformation theory, 279

tri-color fields, 264, 269, 309, 310,  
315–317

Tryon, Edward P., 71, 72, 74

Tye, Henry, 66

## U

Uhlenbeck, George, 193, 280

ultraviolet catastrophe, 41

uncertainty principle, 22, 46, 66, 71, 150,  
184, 185, 196, 197, 209, 218, 278,  
286, 301, 313

unified field theory, 43–45, 48, 124, 321

universe, ix, 8, 10–12, 21, 54–58,  
60–67, 69–73, 76, 77, 79, 83, 90,  
103, 113, 116, 117, 125, 131, 137,  
142, 144, 150, 155, 156, 159,  
171–177, 200, 218–220, 222, 223,  
231, 238, 240, 241, 254, 260, 267,  
302, 305, 307, 309, 311, 312, 315,  
316, 329, 330, 332, 334

Ursinus College, 11, 29, 135, 162, 163

## V

vacuum energy, 69

valence electrons, 192

Vietnam, 6, 7

virtual particles, 247, 248, 256

## W

Watergate, 6

wave function, 205–208, 210–212,  
215–219, 221, 223, 238–240, 246,  
253, 254, 257, 265, 276, 278, 281,  
284, 287, 290, 291, 301, 305, 306,  
310, 312, 321

wave function of the universe, 218, 219,  
222, 224, 310

wave mechanics, 196, 197, 217, 247,  
277–279

wave-particle duality, 42, 43, 78, 184,  
185, 198, 200, 205, 266, 275, 283,  
294, 330

waves, 78, 79, 205, 207, 208, 216–218,  
220, 238, 253–255, 265, 282, 291,  
330, 333

advanced waves, 216, 217, 221

interference, 78, 79, 207, 208, 218,  
283, 330, 331, 333

phase, 207, 208, 253–255, 291, 331  
probability amplitude, 205, 218, 219,  
221, 238, 291

retarded waves, 216, 217, 220

$W^+$  boson, 246–248, 261, 319

$W^-$  boson, 246–248, 261, 319

Weyl, Herman, 253

Wheeler, John Archibald, 215

Wheeler-deWitt equation, 219

Wheeler-Feynman absorber theory,  
215–217

white dwarfs, 317

Wilson, Robert, 61

## Y

Yang, Chen Ning, 254

Yerger, Arthur, vii, 244, 245, 326

Yerger, Chuck, vii, xi, 84, 85, 109, 110,  
132, 133, 244

Yerger, Frances, vii, ix–xi, 10, 51, 52, 164,  
323, 324, 327

Yerger, John, vii, 84, 109, 110, 226, 227,  
272–275, 326

Yerger, Lawrence, vii, x, xi, 10, 29, 53,  
164, 202, 203, 274, 323, 324, 326

Yerger, Mary Ann, vii, 323, 326

## Z

$Z^0$  boson, 246–248, 261, 319

ZBW, 283, 284, 291, 292, 293

Zeeman, Pieter, 190

Zeeman effect, 192

Zitterbewegung, 277, 283, 284, 286,  
288, 291

Zweig, George, 250

Zwicky, Fritz, 68