Philosophy of Special Relativity
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Tutorial 1

"Every particle continues in its state of rest or uniform motion, except insofar as it doesn't." (Eddington)

It is sometimes said that Newton's First Law is just a definition of inertial frame, and that his Second Law is just a definition of force. What, if anything, is the empirical content of Newton's laws?

Core Reading

R. Torretti, *Relativity and Geometry* (Pergamon, 1983; Dover, 1996), 1.1-1.5 (pp. 8-19). *On the notion of an inertial frame.*

H. Poincare, *Science and Hypothesis*, English translation by G.B.Halsted (Science Press, 1913). Chapters VI-VII.

E. Nagel, *The Structure of Science,* 2nd edition (Hackett, 1979), pp. 174-202. (It doesn't matter if you get the older edition).

J. Barbour, *Absolute or Relative Motion? Volume 1: The Discovery of Dynamics* (Cambridge, 1989), reprinted as *The Discovery of Dynamics* (Cambridge, 2001). Pages 19-34, and chapter 12. A popularised version of this account can be found in J. Barbour, *The End of Time?* (Weidenfeld and Nicholson, 1999), chapter 6 (pp. 93-108).

Brown, H.R. *Physical Relativity: Spacetime Structure from a Dynamical Perspective* (OUP 2005), Sections 2.1 and 2.2.

Ellis, B. The origin and nature of Newton's laws of motion. In Colodny (ed.), Beyond the edge of certainty: essays in contemporary science of philosophy, pp.29-68.

Further Reading

a) Geometric approaches

Note: the readings in this section refer to the geometric approach to understanding spacetime structure and inertia. This is an important and popular approach which ideally you should study. The problem is that mathematically speaking it is *difficult*: done properly it involves serious differential geometry, on a level substantially beyond what you've studied so far.

SO: have a look at the article by Earman and Friedman, below. If you can follow the maths, good for you! – if not, skim or skip the mathematically intense sections and see what sense you can make of the rest of the paper.
Alternately or additionally: look at the sections from Friedman's book. He takes the reader rather more gently through the material, but is less incisive.

You may find the chapter from Earman's book helpful in getting a feel for the notions involved here.

J. Earman and M. Friedman, "The Meaning and Status of Newton's Law of Inertia and the Nature of Gravitational Forces", *Philosophy of Science* 40 (1973), pp. 329-359. Available online via TDNet.

M. Friedman, *Foundations of Space-Time Theories* (Princeton, 1983), sections II.1 (pp. 32-45), III.1 (pp. 71-86), III.6-II.7 (pp. 108-120).

J. Earman, *World Enough and Space-Time?* (MIT, 1989), chapter 2 (pp. 27-40).

b) Other readings

J. Anderson, "Newton's first two laws of motion are not devoid of empirical content", *American Journal of Physics* 58 (1990), pp. 1192-5. Available online via TDNet.
(Physicist's account; some advanced maths.)

H. Brown, *Physical Relativity* (Oxford, 2006), chapter 2: "The Physics of Coordinate Transformations" (pp. 11-32).

R. DiSalle, "Space and Time: Inertial Frames", *Stanford Encyclopedia of Philosophy (Summer 2002 edition),* E. N. Zalta (ed.), available at
http://plato.stanford.edu/archives/sum2002/entries/spacetime-iframes/ . Sections 1.1 – 2.1.

R. Lindsay and H. Margenau, *Foundations of Physics* (Wiley, 1936), pp. 85-98.

Tutorial 2

Essay task: Write an essay answering *all* of the following:

What role do the Relativity Principle and the Light Postulate play in the derivation of the Lorentz transformations?

On the Light Postulate: What is the distinction between saying that the light speed is *source-speed independent*, that it is *isotropic*, and that it is *invariant*; and which of these should we interpret the "constant" in Einstein's Light Postulate to include?

On the Relativity Principle: It is sometimes suggested that the Newtonian principle of relativity is expressed in our freedom to transform coordinate systems by a Galilean transformation, the special principle of relativity in our freedom to transform by a Lorentz transformation. Do you agree?

Core Reading

J. Norton, "Philosophy of space and time", section 5.1 (pp. 180-183). In M. H. Salmon (ed.), *Introduction to the philosophy of science* (Prentice-Hall, 1992/1999). Available for download from http://www.pitt.edu/~jdnorton/papers/PST-1.pdf .

A. Einstein, "On the electrodynamics of moving bodies", in H. Lorentz, A. Einstein *et al*, *The Principle of Relativity* (Dover, 1952); alternative translation in A. I. Miller, *Albert Einstein's Special Theory of Relativity* (Addison-Wesley, 1981); available online at http://www.fourmilab.ch/etexts/einstein/specrel/www/ .
Part 1 (sections 1-5).

H. R. Brown, *Physical Relativity* (Oxford, 2006). Chapter 3 (pp. 33-40) and Chapter 5 (pp. 69-90). Available online from Oxford Scholarship Online.

E. F. Taylor and J. A. Wheeler, *Spacetime Physics*, 2nd edition (W.H.Freeman, 1992). Chapter 3 and Special Supplement (pp. 53-120).
NB this is in part a textbook; many parts can be skimmed or skipped as of limited philosophical interest.

H. R. Brown and R. Sypel, "On the meaning of the relativity principle and other symmetries", *International Studies in the Philosophy of Science* 9 (1995), pp. 235-53, esp. sections 2-3.

Further Reading

R. Torretti, *Relativity and Geometry* (Pergamon, 1983; Dover, 1996), chapter 3 (pp. 48-87).
Alternative discussion of the derivation of the Lorentz transformations, for the more mathematically minded.

M .Friedman, *Foundations of Space-Time Theories* (Princeton, 1983), sections IV.1,IV.2, IV.5 (pp. 125-141 and 149-158).
An account of the very different, spacetime-geometry-centric, approach to the Lorentz transformations.

Tutorial 3

Simultaneity is variously described as "relative" and "conventional". What do these claims mean, and which, if either, is true?

Core Reading

A. Janis, "Conventionality of Simultaneity", *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/fall2008/entries/spacetime-convensimul/>.
An introductory overview.

J. Norton, "Philosophy of space and time", sections 5.3 (pp. 190-194) and 5.11 (pp. 222-226). In M. H. Salmon (ed.), *Introduction to the philosophy of science* (Prentice-Hall, 1992/1999). Available for download from http://www.pitt.edu/~jdnorton/papers/PST-1.pdf (for section 5.3), and http://www.pitt.edu/~jdnorton/papers/PST-3.pdf (for section 5.11).
Another overview.

H. Reichenbach, *Space and Time* (Dover, 1958), pp. 123-135.
One of the classic historical loci of the conventionalist view (the other being Grunbaum), and still one of the clearest.

R. Torretti, *Relativity and Geometry* (Pergamon, 1983) pp. 220-230.
A textbook discussion of the conventionality issue, more advanced than Janis. Surveys the historical development of the discussion, from Kant through Reichenbach, Grunbaum and Winnie. Concludes against conventionalism.

W. Salmon, "The Philosophical Significance of the One-Way Speed of Light",
Noûs, Vol. 11, No. 3, Symposium on Space and Time (Sep., 1977), pp. 253-292.
Pro-conventionalist.

D. Malament, "Causal Theories of Time and the Conventionality of Simultaneity", *Nous* 11 (1977), pp. 293-300. Available online via TDNet.
Proves that the standard (Einstein) synchrony relation is the only one that is "definable in terms of the causal structure of spacetime and the given inertial worldline", in a precisely specified sense. Widely, but not universally, taken to be a decisive refutation of the conventionalist view.

H. R. Brown, *Physical Relativity* (Oxford, 2006), pp. 95-105.
Pro-conventionalist.

Further Reading

R. B. Angel, *Relativity: the Theory and its Philosophy* (Pergamon, 1980), pp. 125-138.

Ellis, B. and Bowman, P. 1967. "Conventionality in Distant Simultaneity," *Philosophy of Science* **34**, 116-136.

M Friedman, *Foundations of Space-Time Theories* (Princeton, 1983), pp. 165-176.
A geometric perspective. [Covers the same material as some of the above?]

S. Sarkar and J. Stachel, “Did Malament Prove the Non-Conventionality of Simultaneity in the Special Theory of Relativity?”, *Philosophy of Science* 66 (1999), pp. 208-220. Available online via TDNet.
Argues that Malament’s assumption that the simultaneity relation must be time-reversal invariant is unjustified, and hence that his theorem fails to establish the inconsistency of the conventionality thesis and the causal theory of time.

J. A. Winnie, “Special Relativity without One-Way Velocity Assumptions: Parts I and II. *Philosophy of Science* 37 (1970) pp. 81-99 and 223-238. Available online via TDNet.
More mathematical detail on the conventionality argument.

Tutorial 4

Does the geometry of spacetime (as specified by the Minkowski metric) play an explanatory role in special relativity?

Core Reading

R. B. Angel, *Relativity: the Theory and its Philosophy* (Pergamon, 1980), pp. 81-90.

J. Norton, "Philosophy of space and time", sections 5.4-5.8 (pp. 195-219). In M. H. Salmon (ed.), *Introduction to the philosophy of science* (Prentice-Hall, 1992/1999). Available for download from http://www.pitt.edu/~jdnorton/papers/PST-2.pdf .
An introduction explaining many of the concepts dear to the spacetime-geometry-realists' hearts, without appealing to differential geometry.

R. Torretti, *Relativity and Geometry* (Pergamon, 1983) chapter 4, sections 4.1-4.4 (pp 88-114)
(A geometric account)

G. Nerlich, *The Shape of Space* (Cambridge, 1976), 10.1-10.9 (pp. 213-251) and possibly also chapter 2 (pp. 29-49), esp. sections 2.7-2.8.

J.S. Bell, "How to Teach Special Relativity", in *Speakable and Unspeakable in Quantum Mechanics* (Cambridge, 1987), pp. 67-80.

H. R. Brown, *Dynamical Relativity* (Oxford, 2006), chapter 8 (pp. 128-149).

Y. Balashov and M Jansen, "Presentism and Relativity", *British Journal for the Philosophy of Science* 54 (2003), pp. 327-346. Available online via TDNet.

Further Reading

H. R. Brown and O. Pooley, "The origin of the spacetime metric: Bell's "Lorentzian pedagogy" and its significance in general relativity", in C. Callender and N. Huggett (eds.) *Physics Meets Philosophy at the Planck Scale* (Cambridge, 2001), pp. 256-272. Available online at http://arxiv.org/abs/gr-qc/9908048 . Sections 1-4 and 6
Further discussion of Bell's position and its philosophical consequences.

M Friedman, *Foundations of Space-Time Theories* (Princeton, 1983), chapter VI (pp. 216-263, esp., pp. 236-263).
Seminal but rather technical account of the geometric viewpoint

E. Taylor and J.A. Wheeler, *Spacetime Physics* 2nd edition (W.H. Freeman, 1992), pp. 137-163.
Using geometry to explain in practice