

Title: Why Constructive Relativity Fails

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Abstract: Are time and space independently existing entities? Or is their existence secondary in that they are merely properties of other, more fundamental physical systems?

The parameters of this enduring debate have shifted according to the physical theory in which it are set. In the 17th century, Newton's notions of Absolute Time and Space strongly favored the idea of independently existing times and spaces. Yet Leibniz famously plagued Newton by pointing to changes that Newton must suppose real even though they issued in no observable differences. Most recently, with the advent of general relativity and quantum theories of gravity that seek to incorporate it, the balance has shifted once again. Is the independence of space and time now finally revealed by the metric field of space and time absorbing the matter of the gravitational fields? Or has time and space has lost its independence from matter in so far as space and time have been absorbed into the matter of the gravitational field?

The focus of my talk will be an intermediate episode of this debate that plays out in the context of special relativity. Lorentz noted that moving electro-dynamical systems slow in time and shrink in space. The realist tradition explains this slowing and shrinking through the adaptation of matter fields to a real, independently existing Minkowski spacetime. A dissident constructive tradition has long felt that the reverse is the case. These spatio-temporal effects are best explained by the properties of matter theories, most notably, their Lorentz covariance. Harvey Brown has advocated a form of this latter constructivism in his *Physical Relativity: Space- time Structure from a Dynamical Perspective*.

This debate between these two views has proven hard to resolve. That is largely because the notion of explanation is not sufficiently understood for us to adjudicate cleanly between competing claims of what explains what better. In my talk, I will review a new approach to the debate. Constructivists have tacitly assumed a technical result, that it is indeed possible to construct a Minkowski spacetime from Lorentz covariant matter theories. I will show that this is incorrect. This construction project can succeed only in so far as constructivists presume antecedently the basic tenets of the realist view of spacetime. Hence constructivism fails as an alternative to realism about spacetime.

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Time and space are primary in our ontology.

How do time and space get into physical theories?



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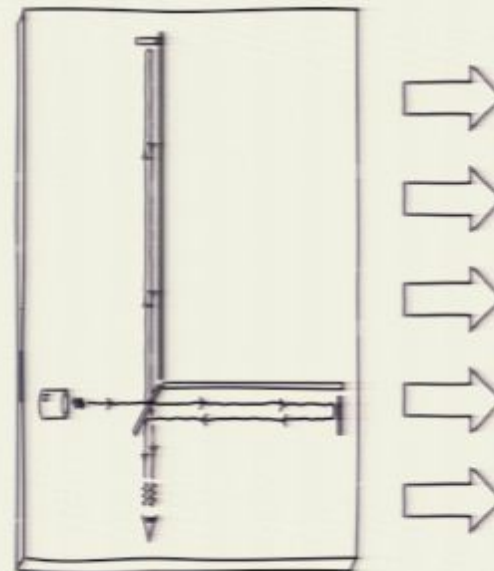
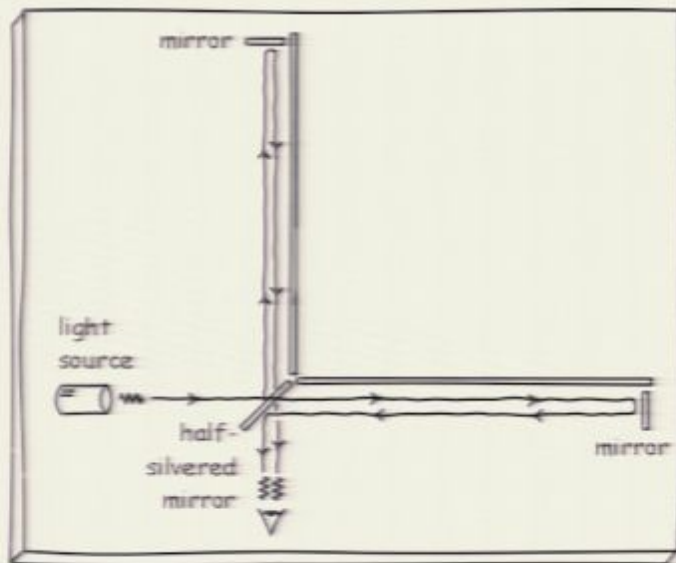


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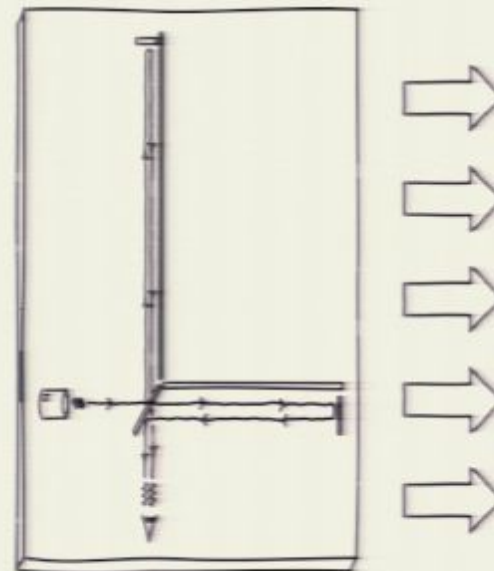
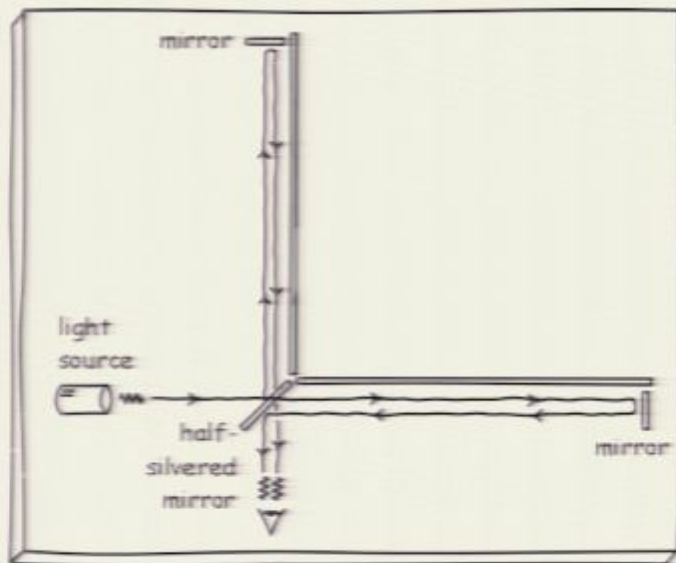
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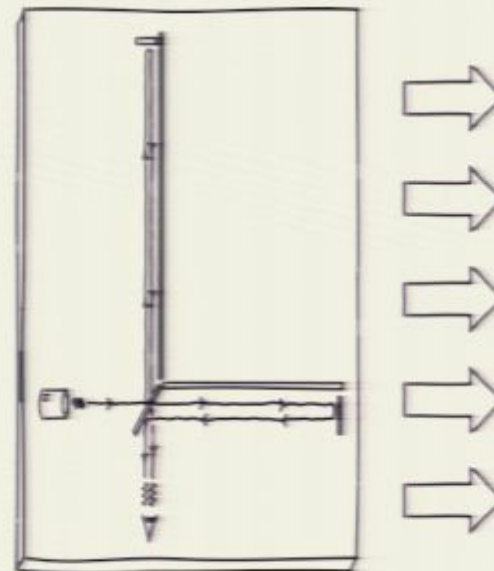
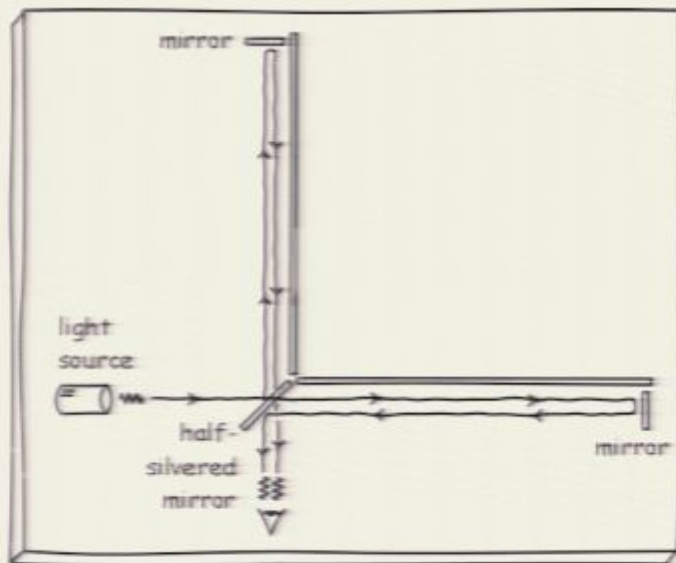
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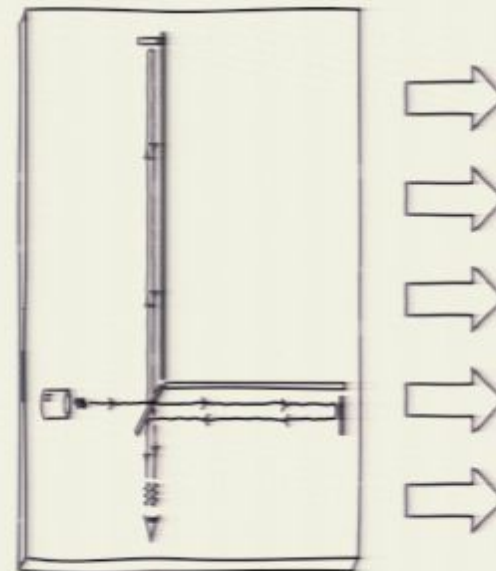
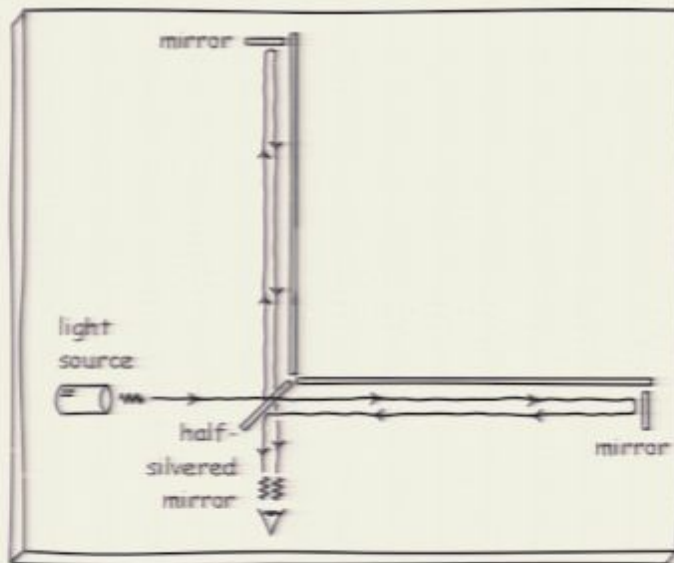
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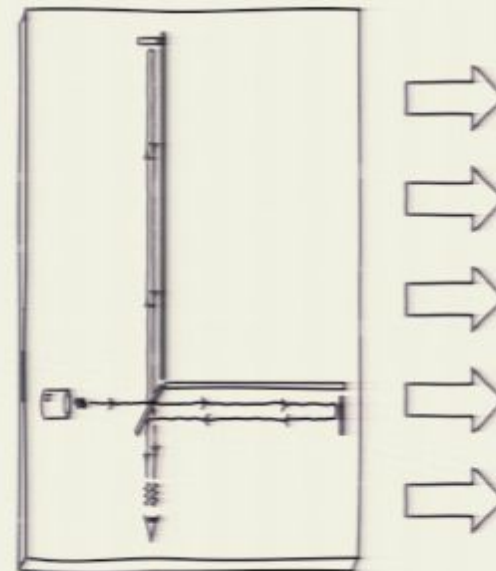
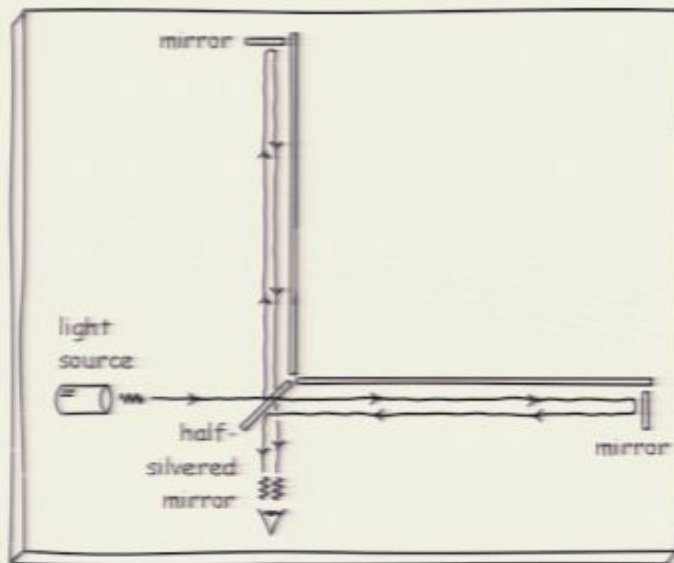
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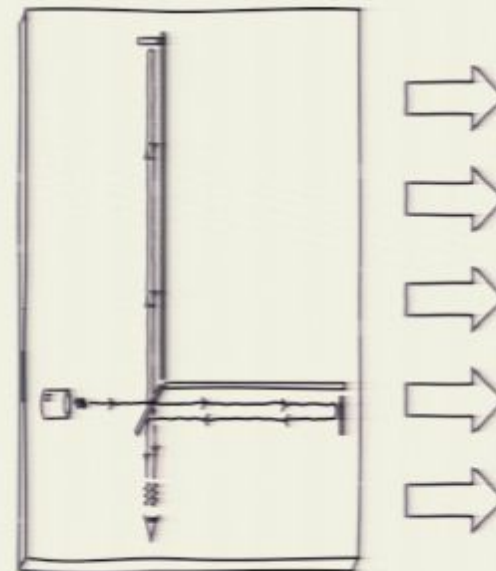
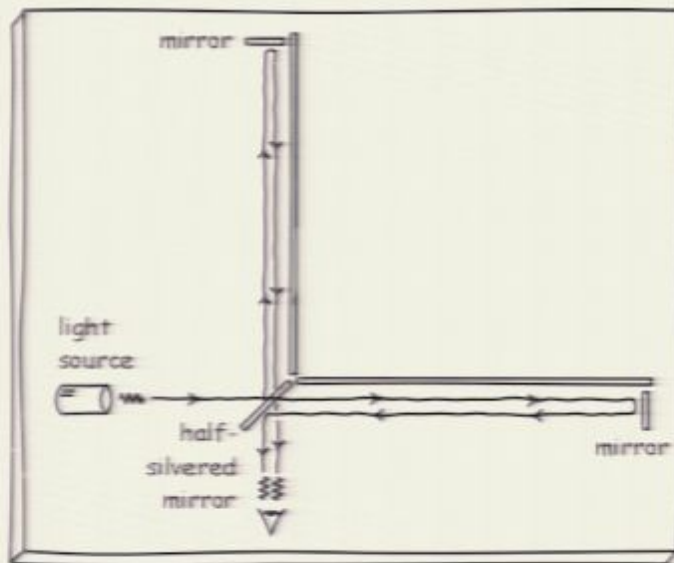
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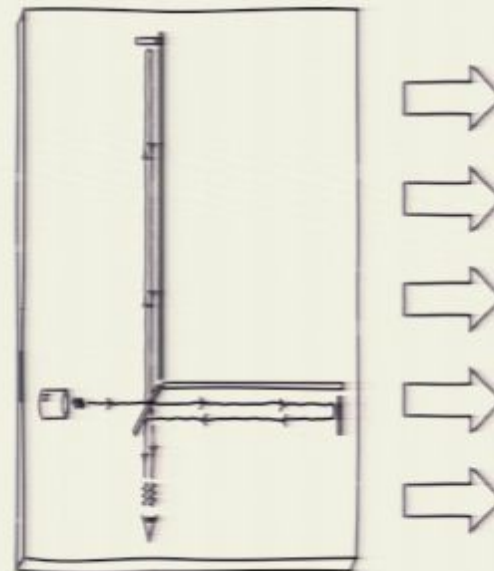
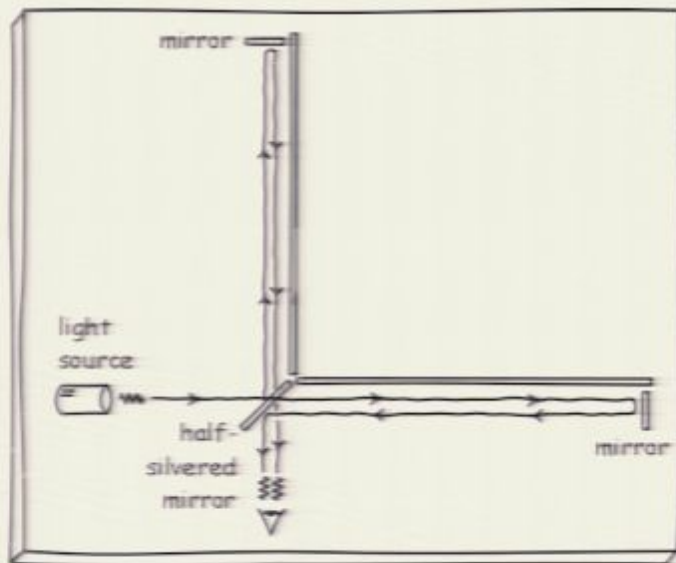
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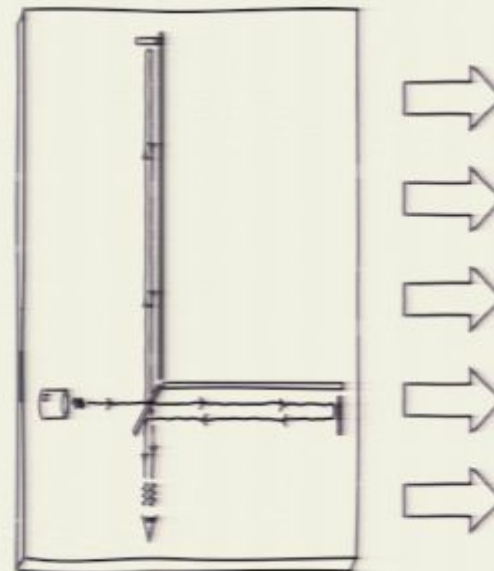
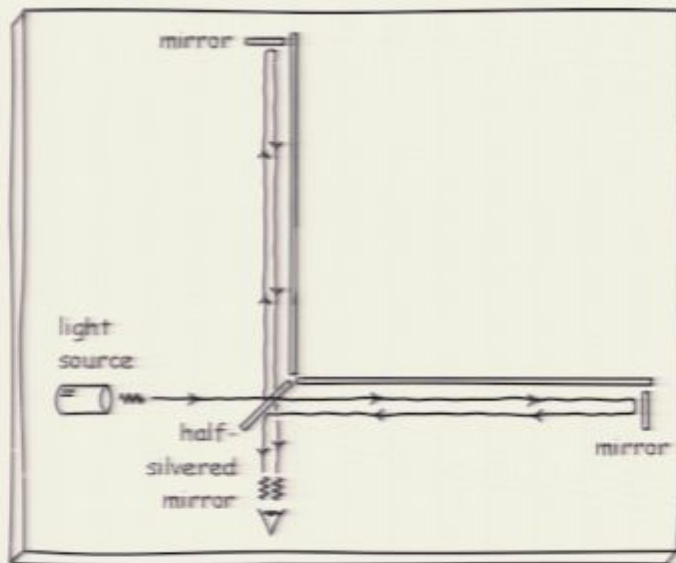
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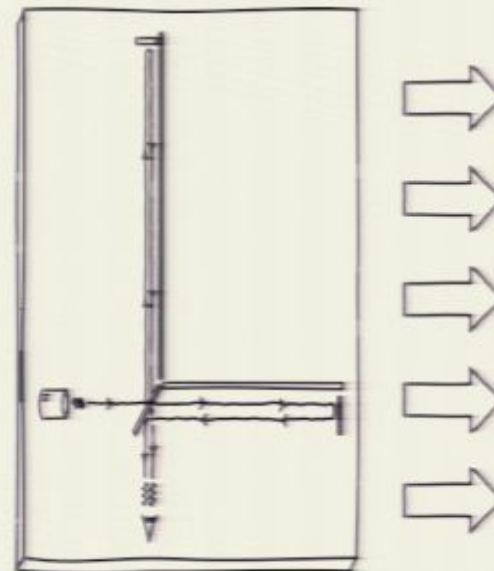
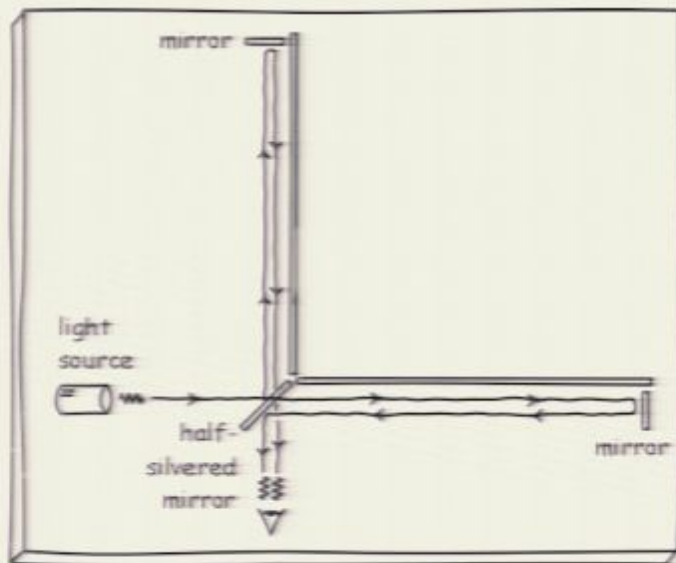
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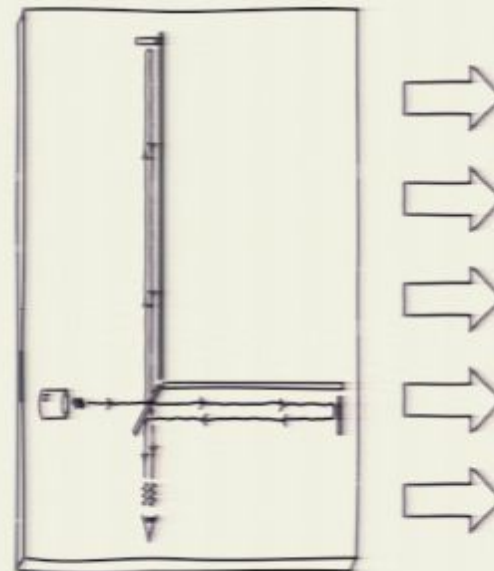
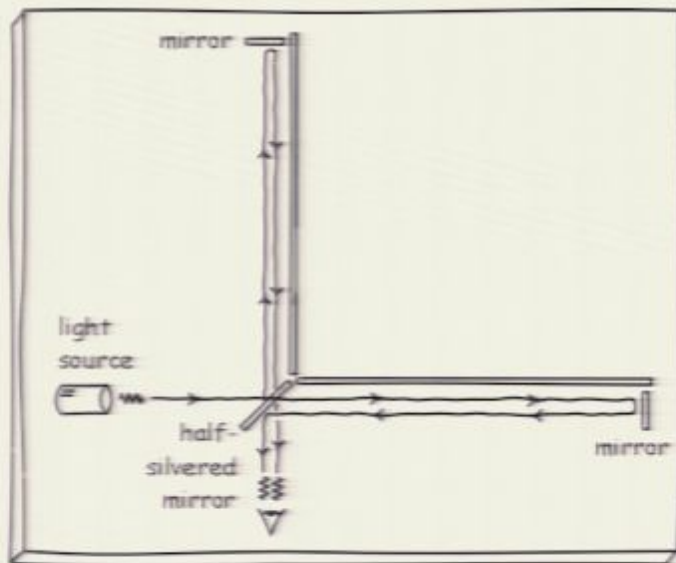
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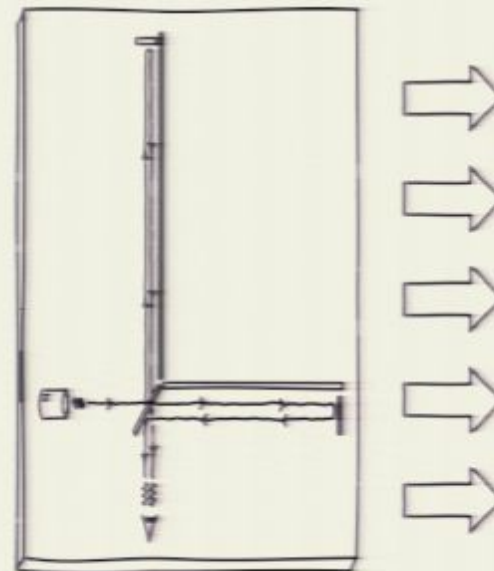
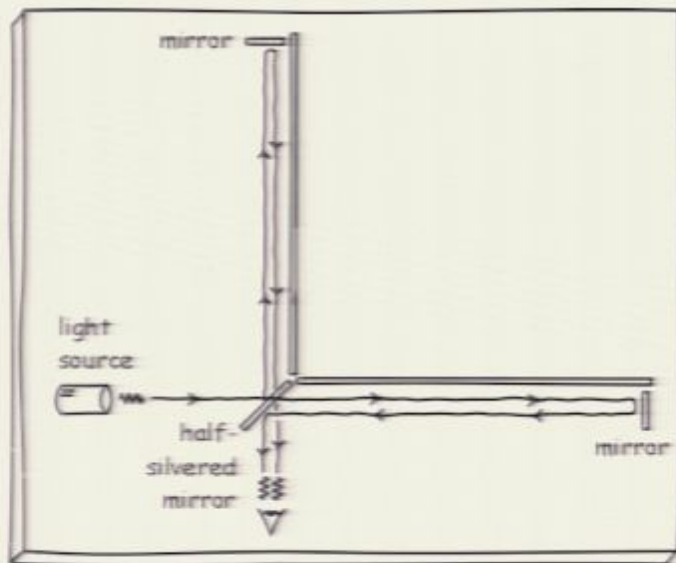
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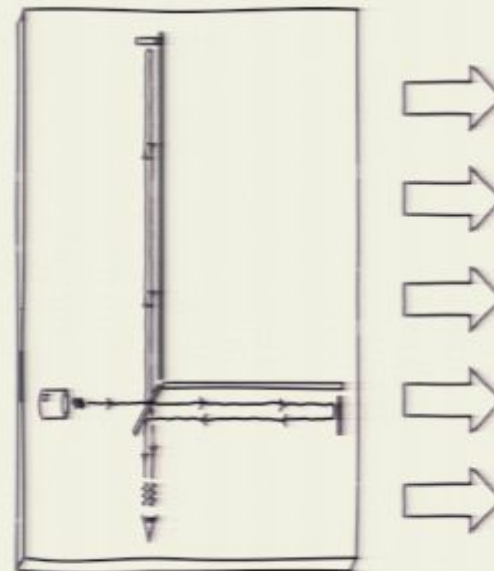
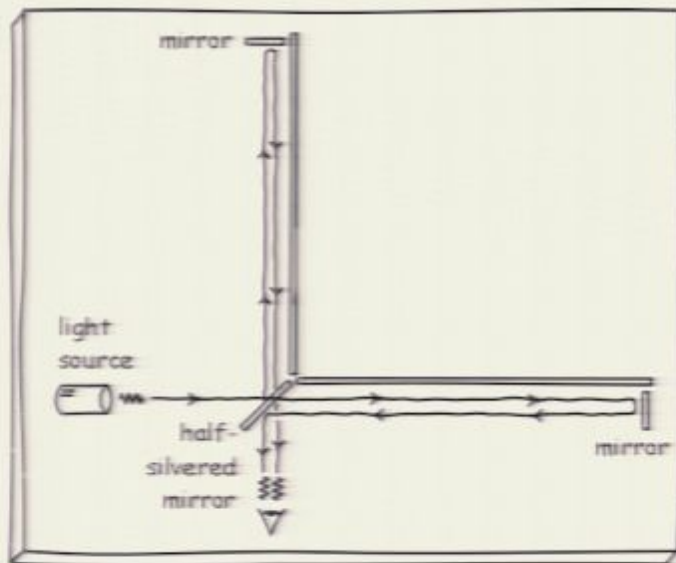
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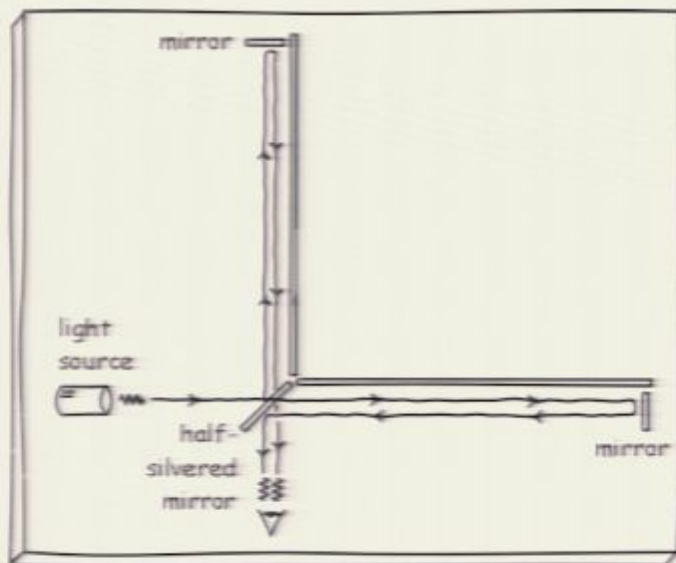
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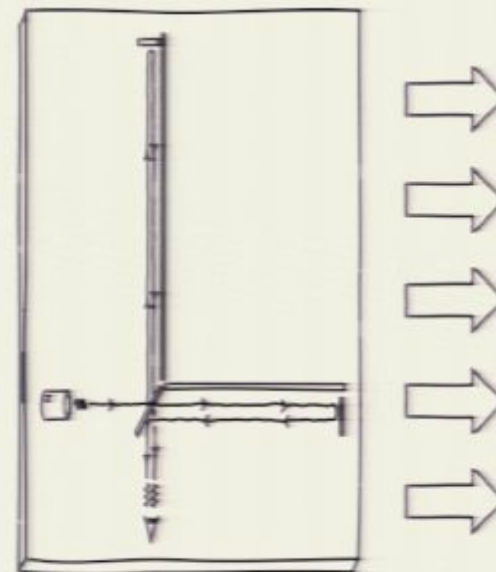


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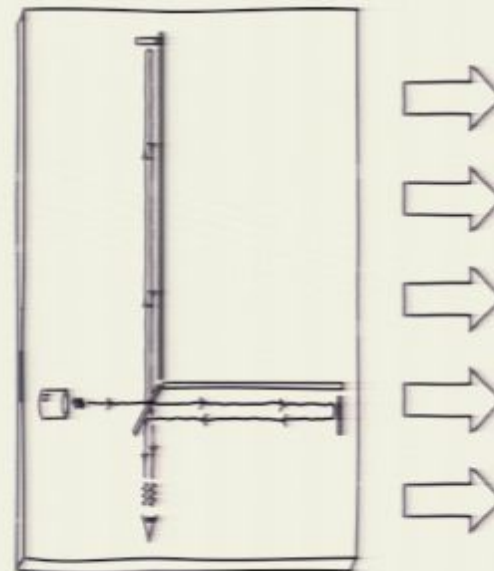
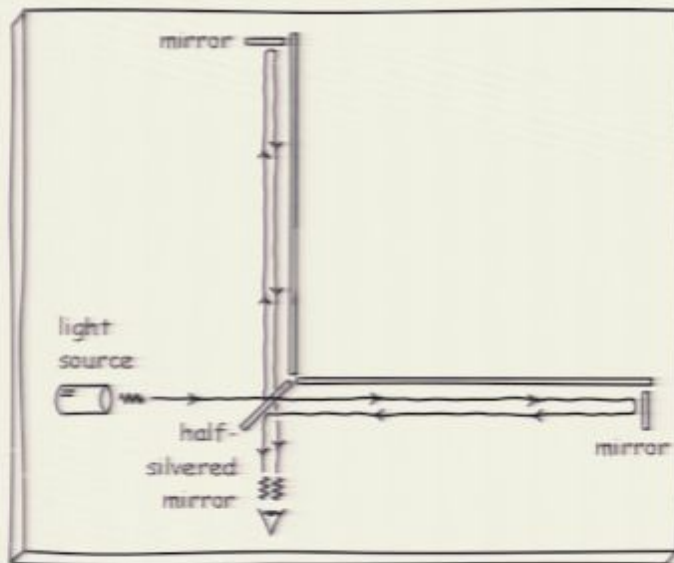
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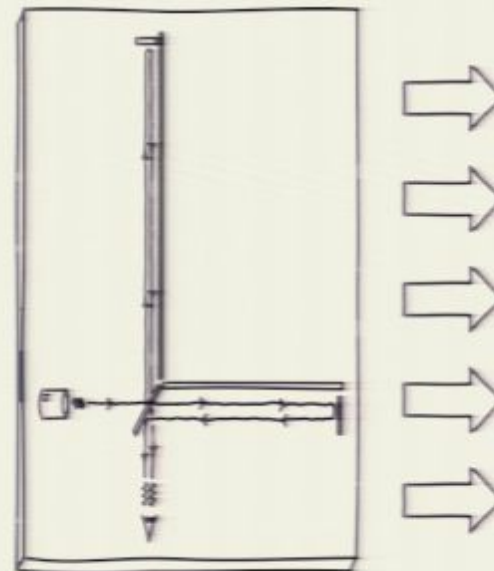
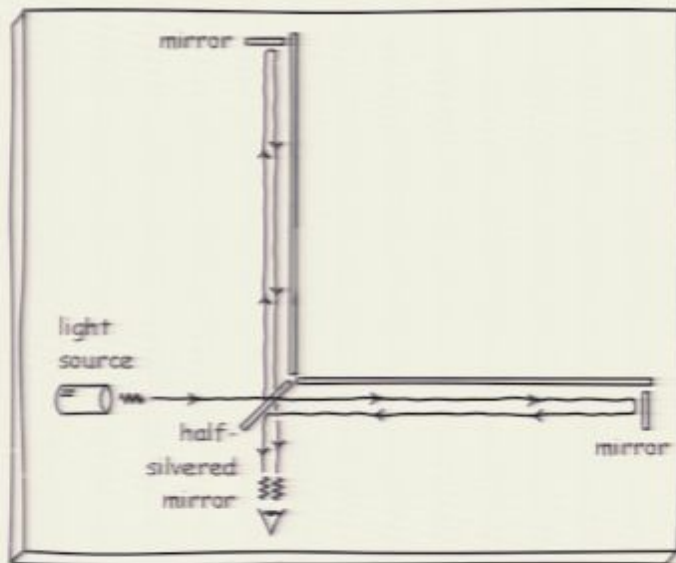
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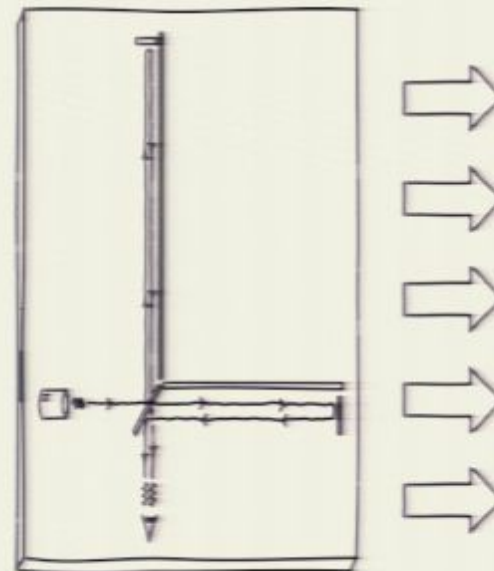
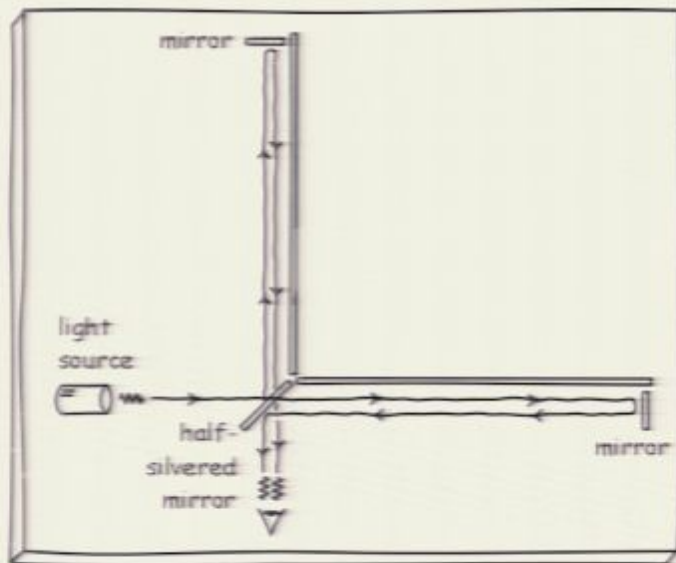
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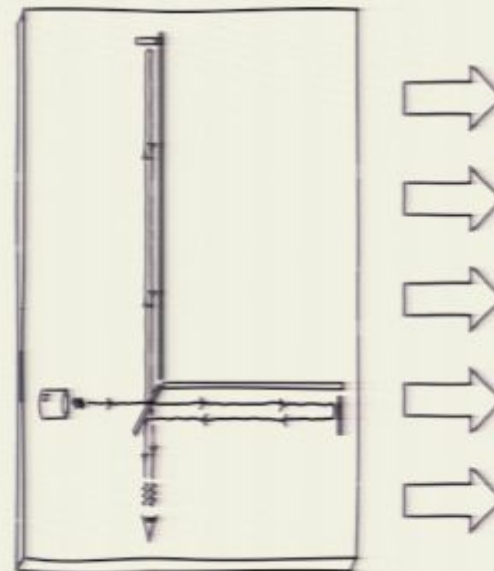
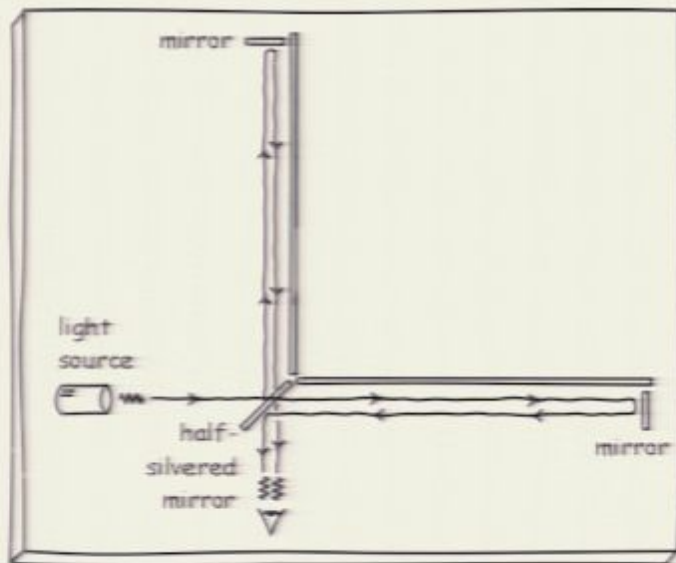
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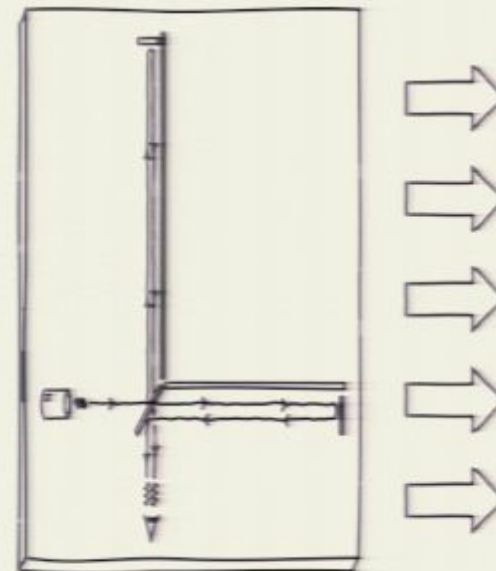
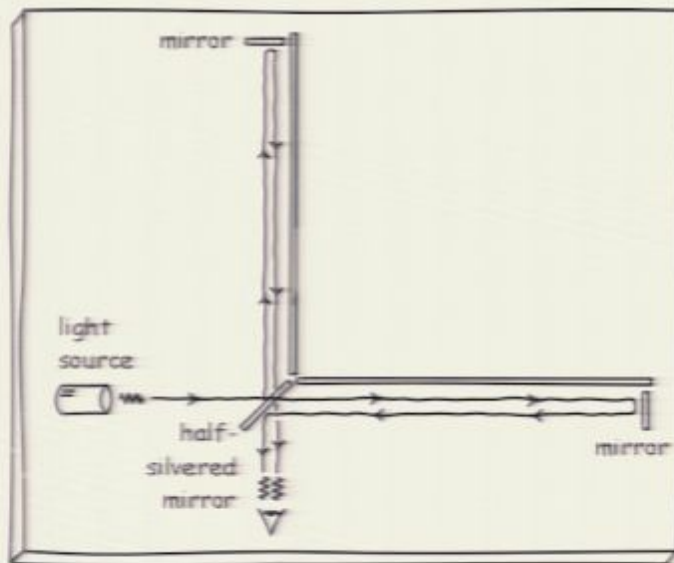
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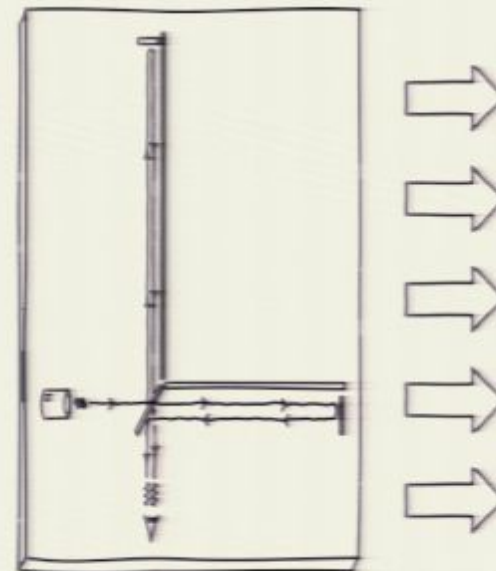
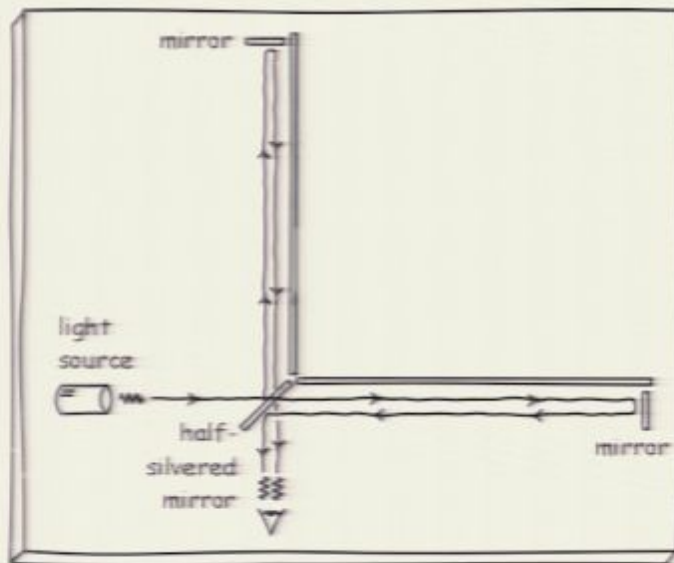
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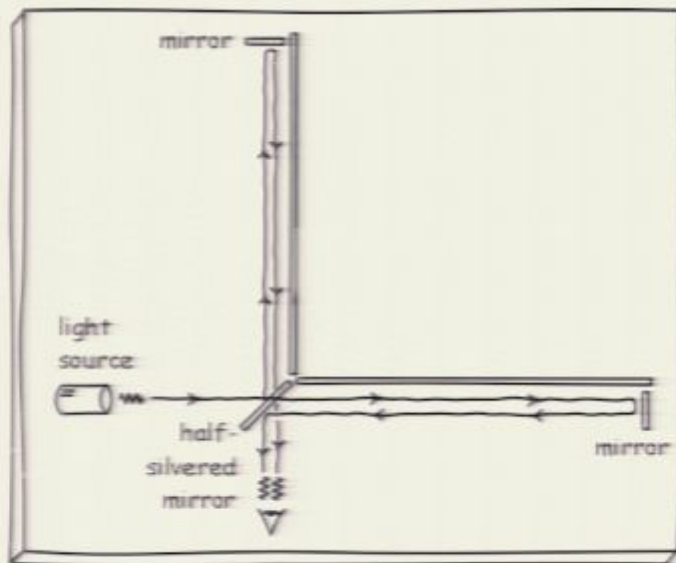
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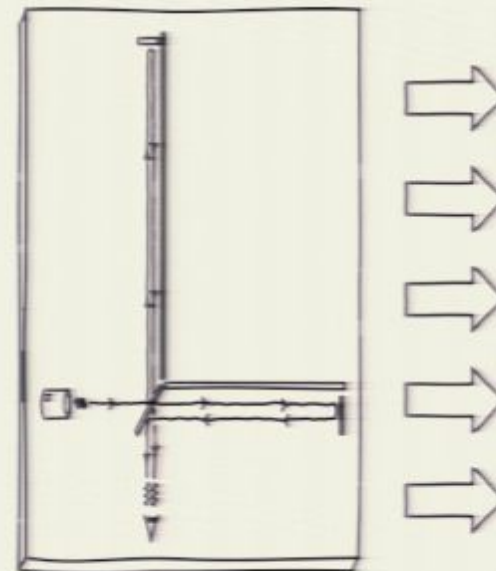


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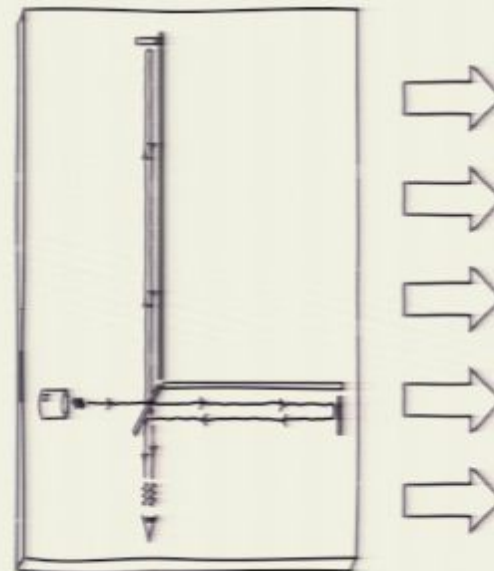
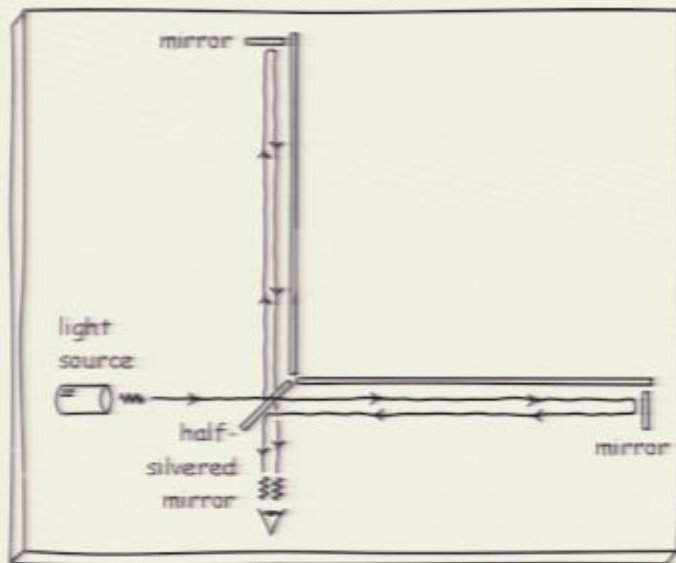
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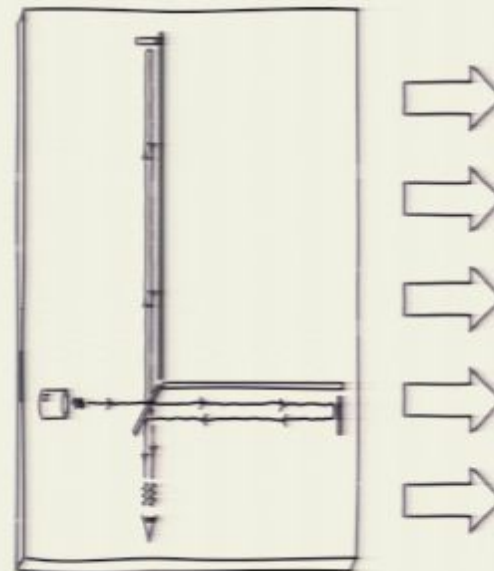
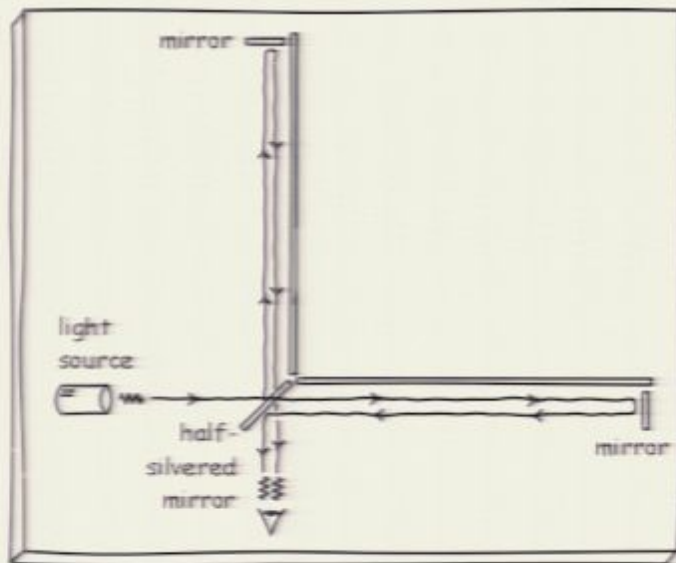
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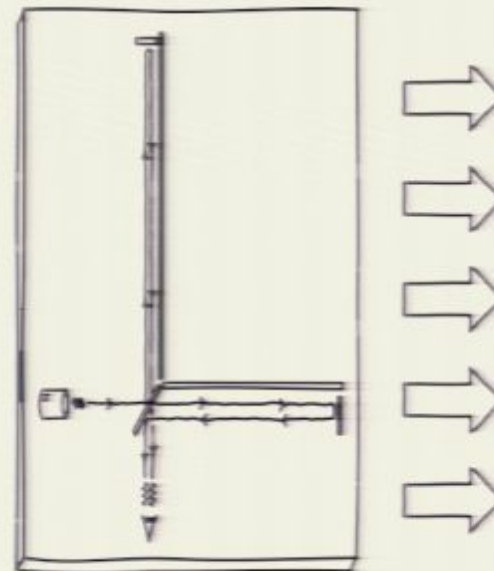
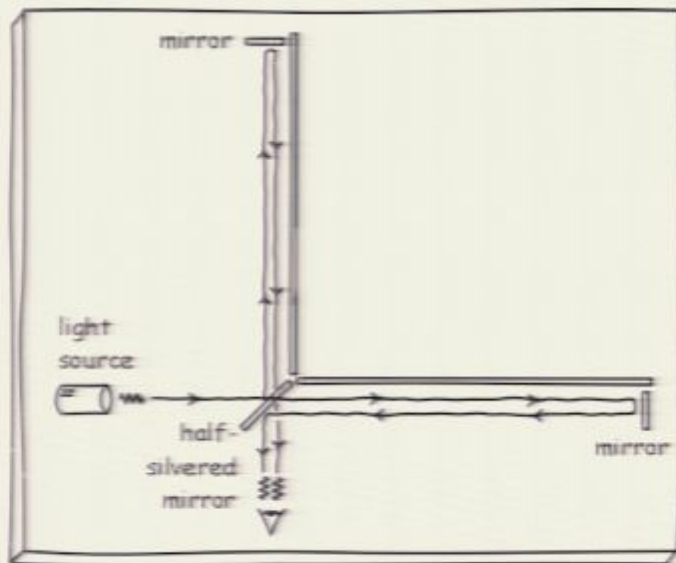
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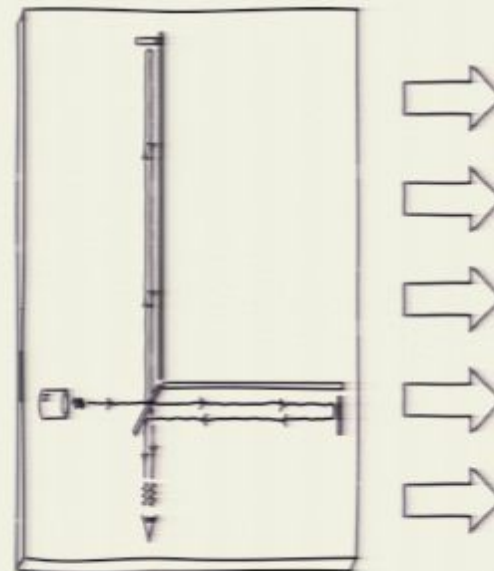
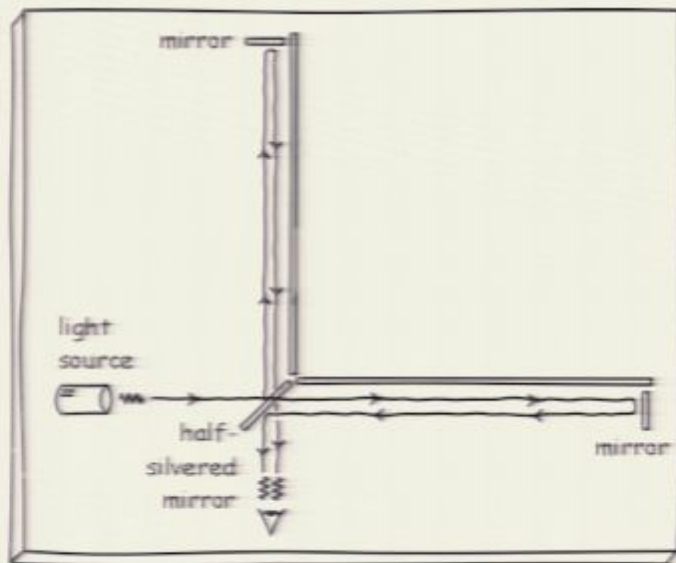
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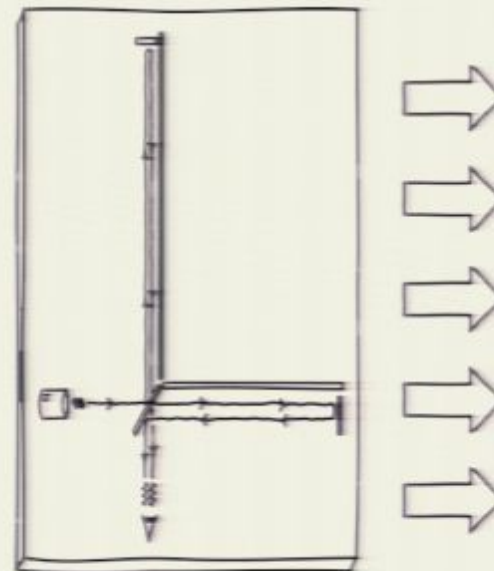
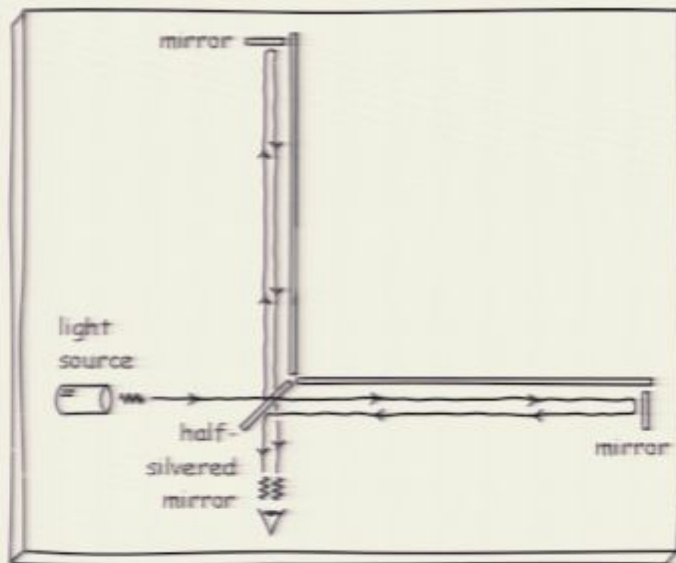
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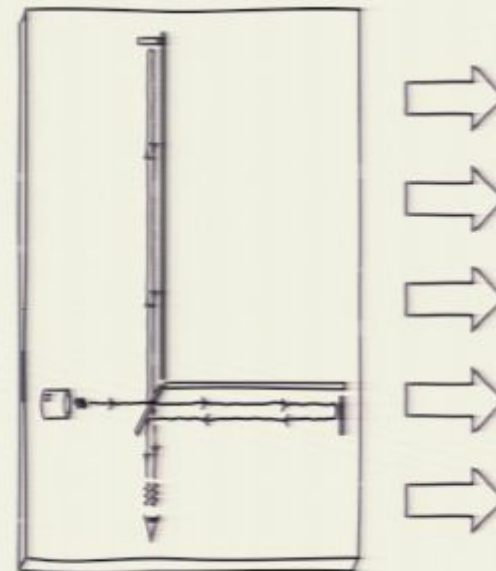
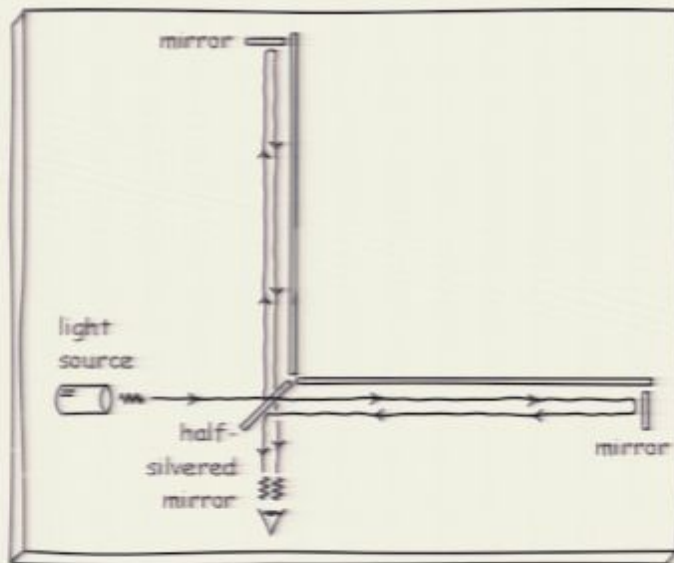
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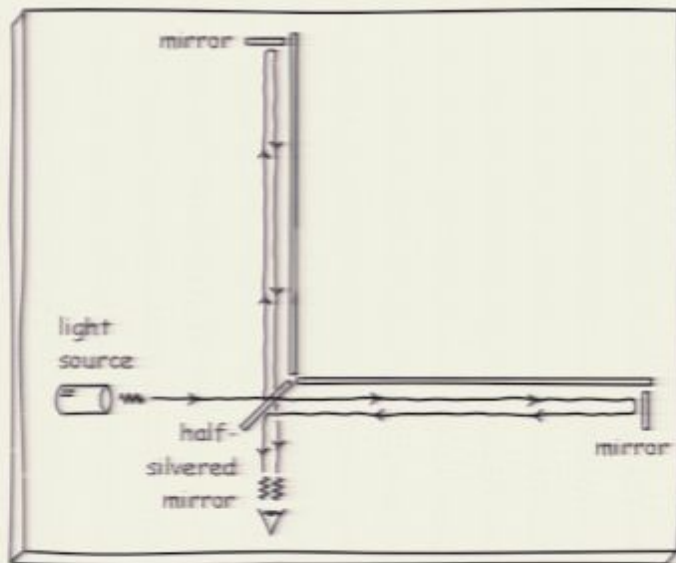
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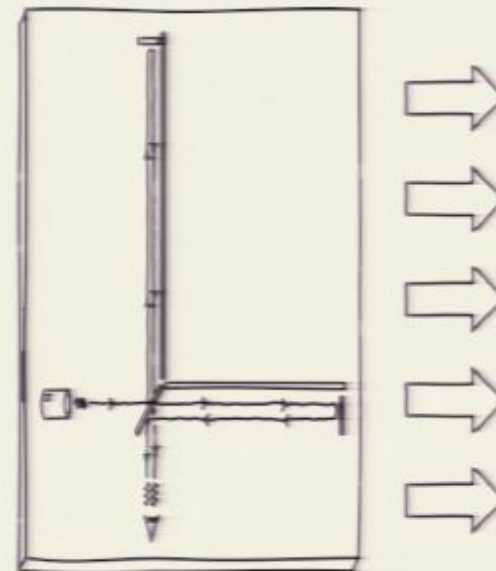


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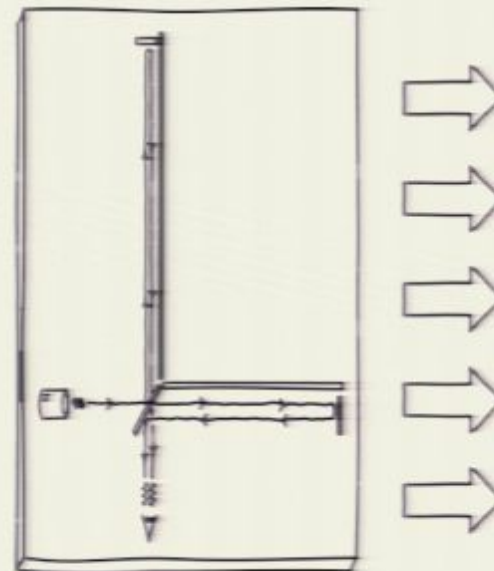
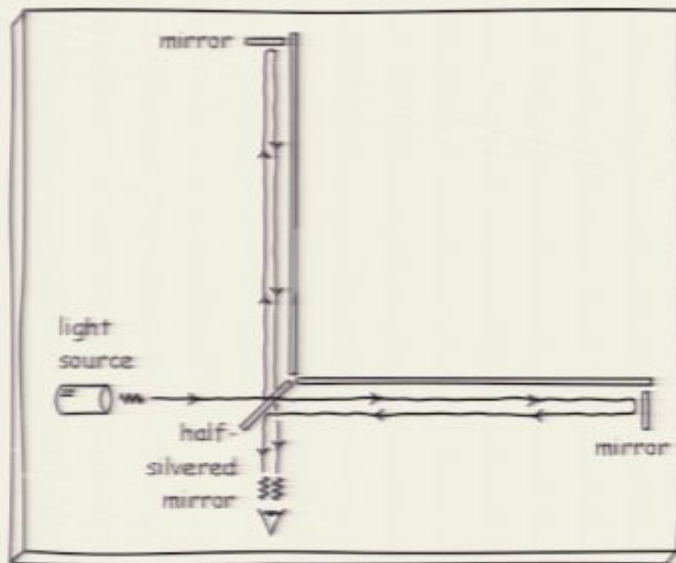
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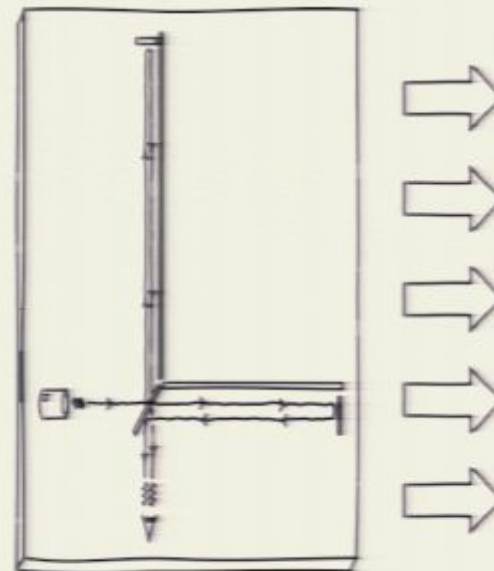
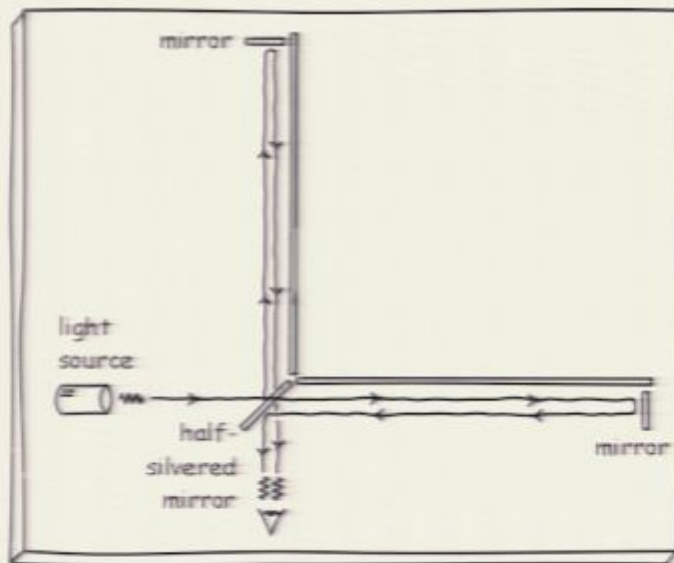
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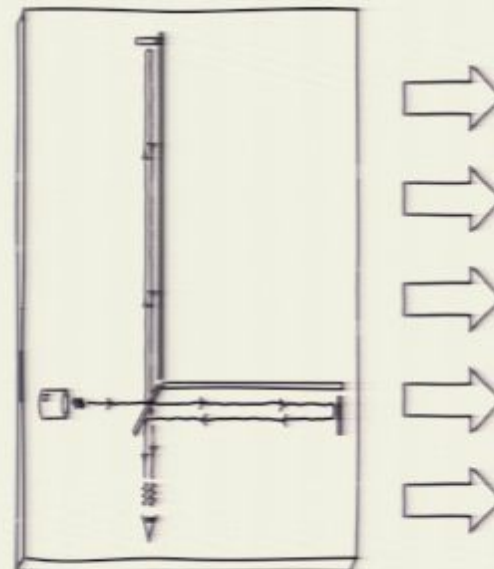
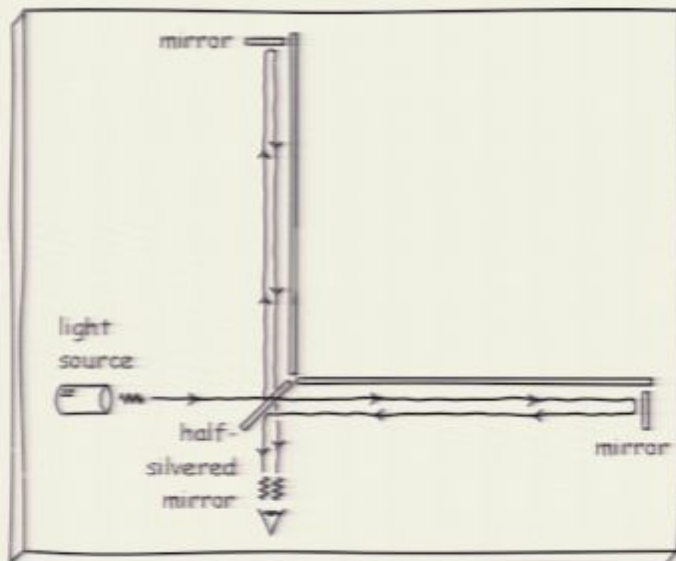
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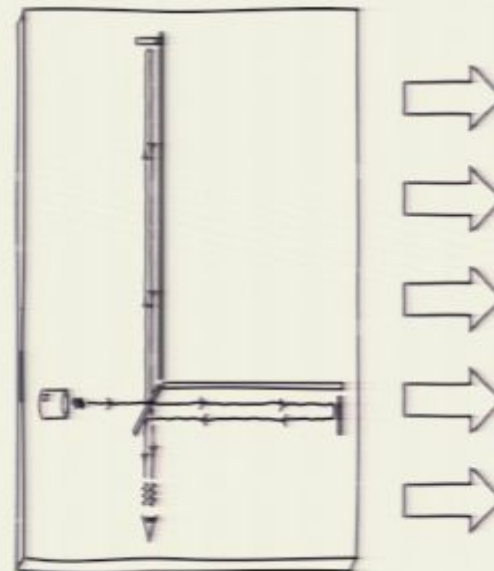
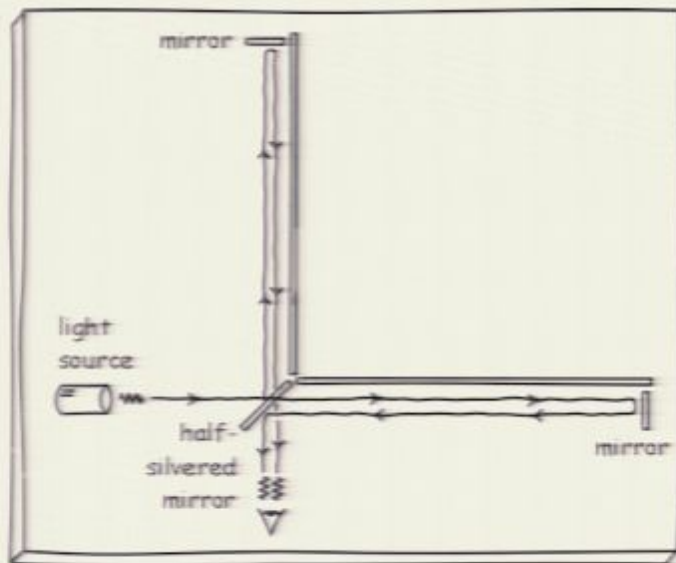
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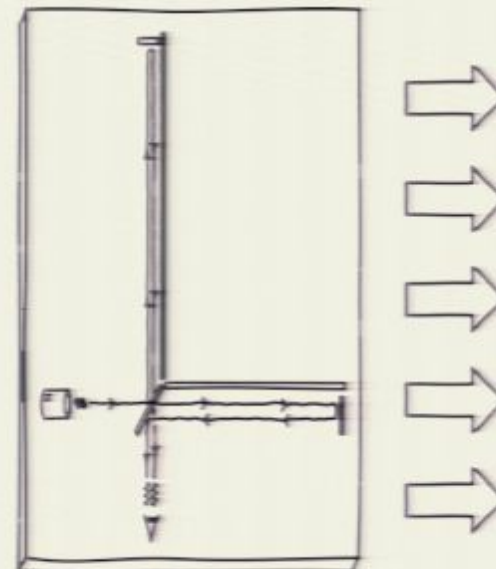
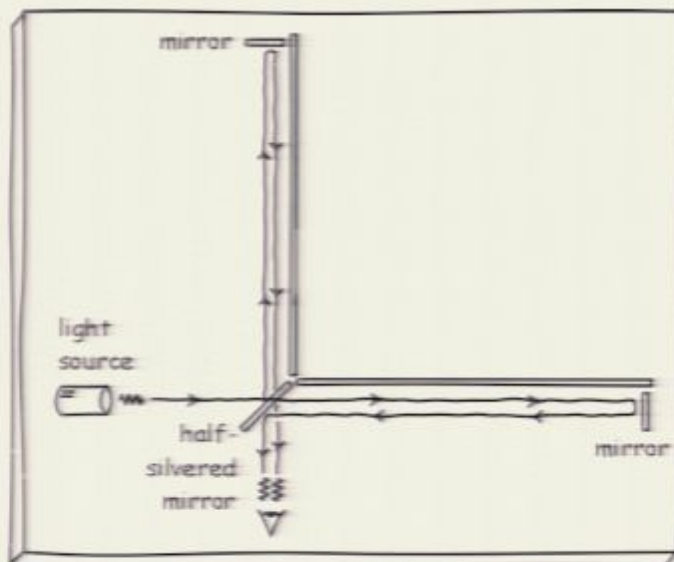
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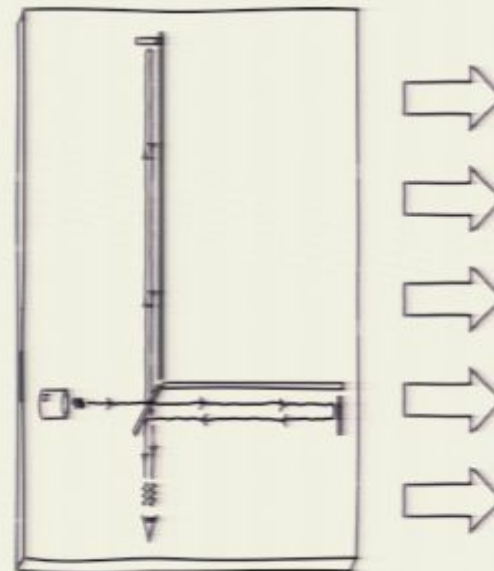
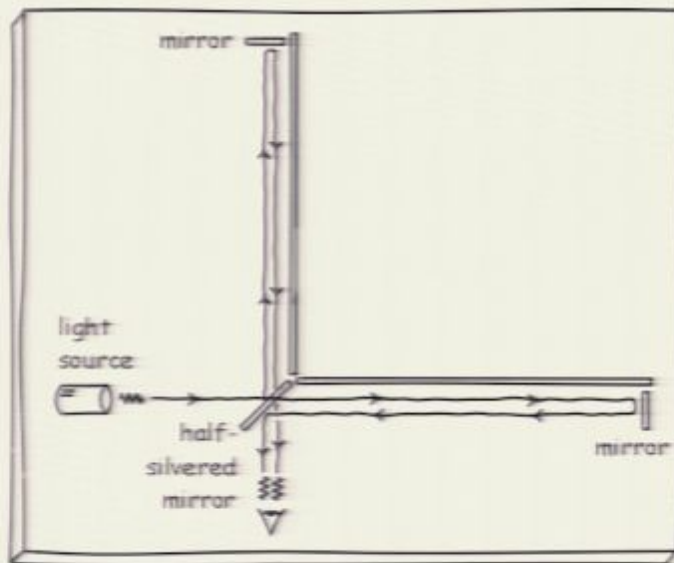
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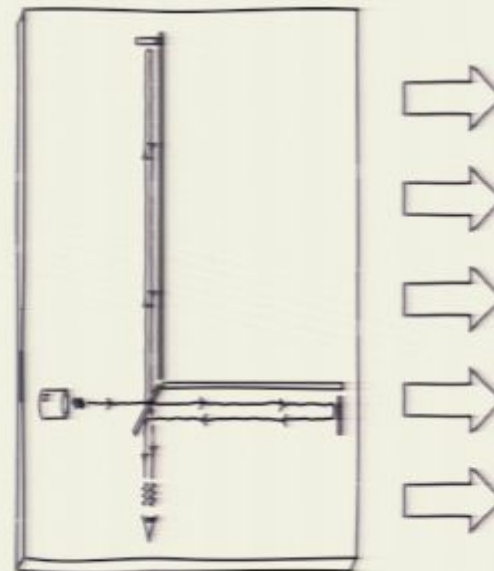
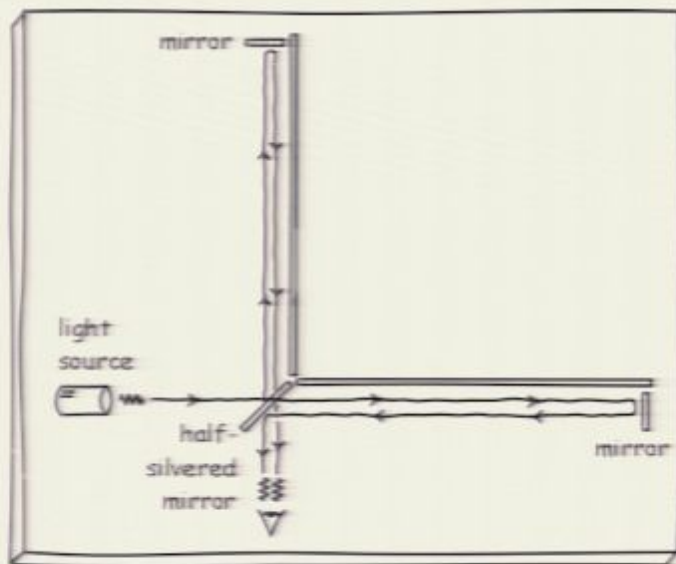
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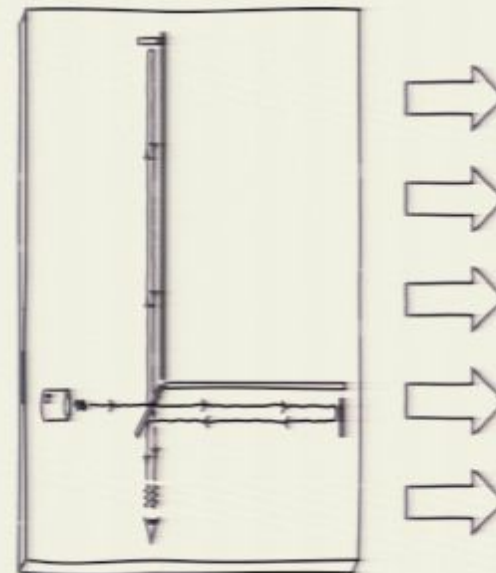
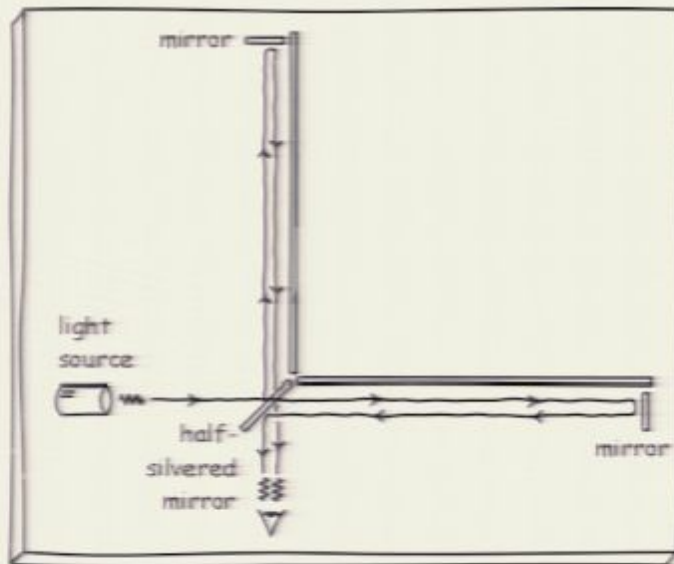
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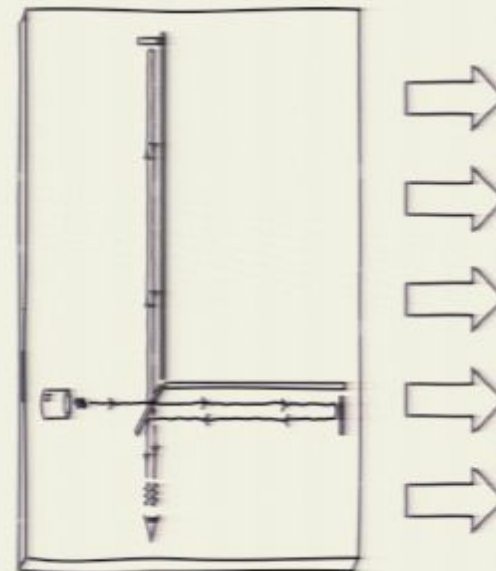
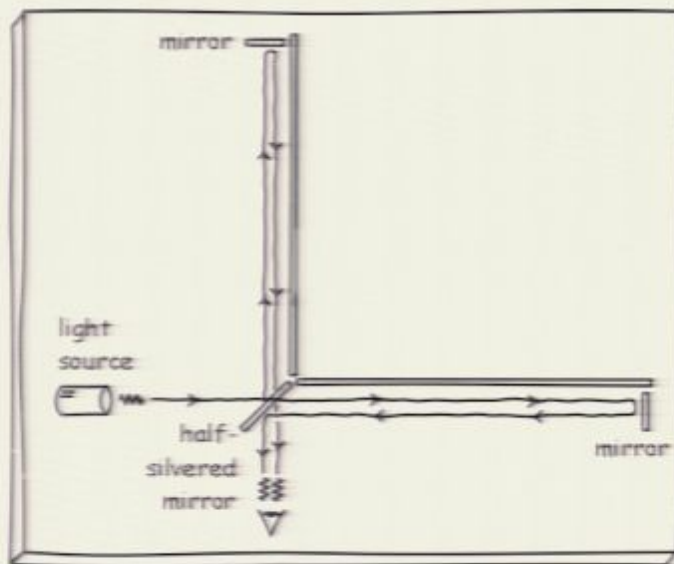
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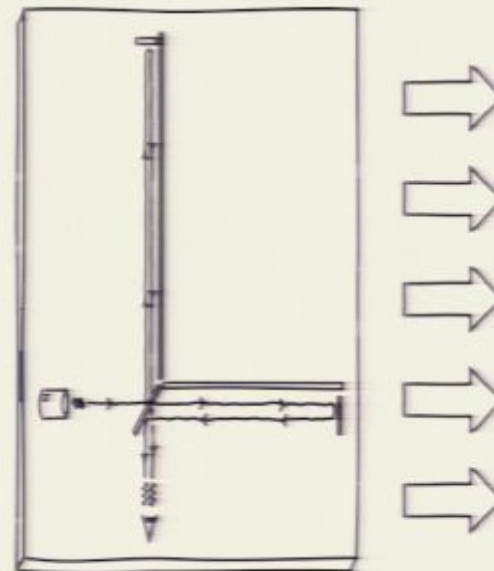
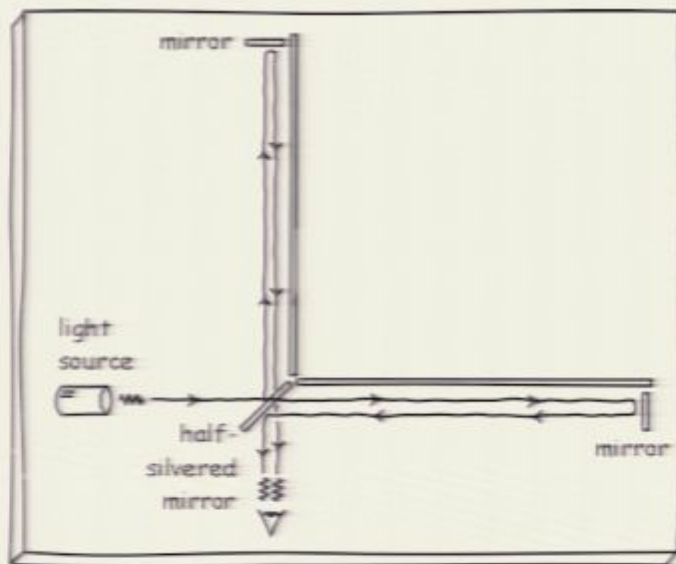
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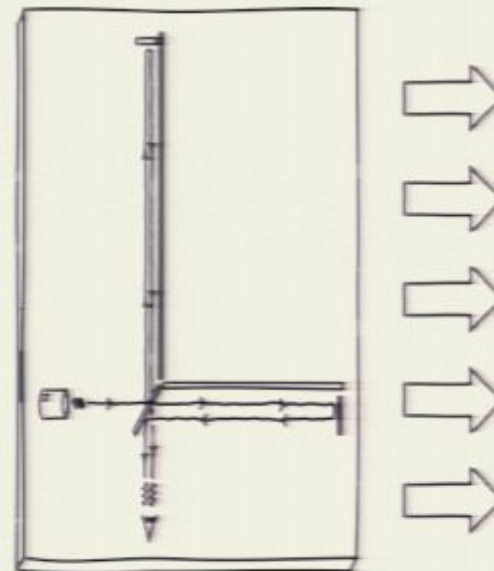
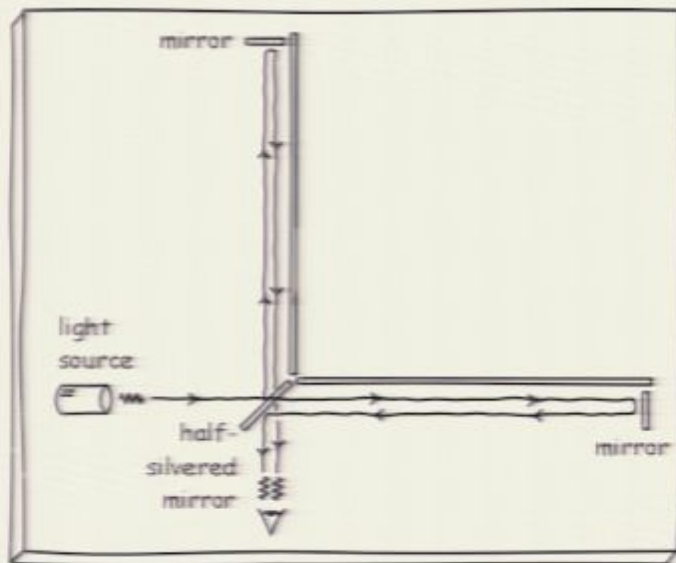
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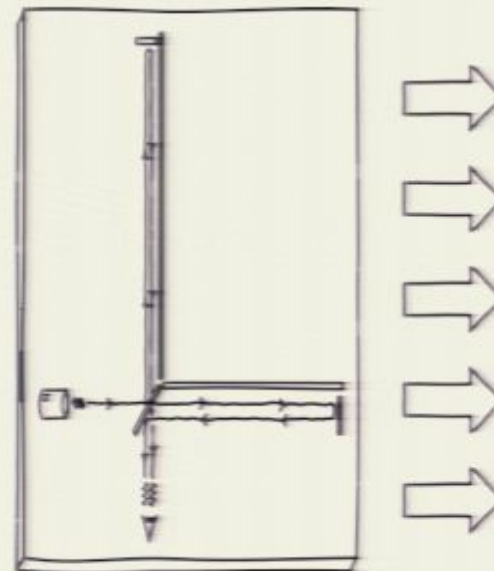
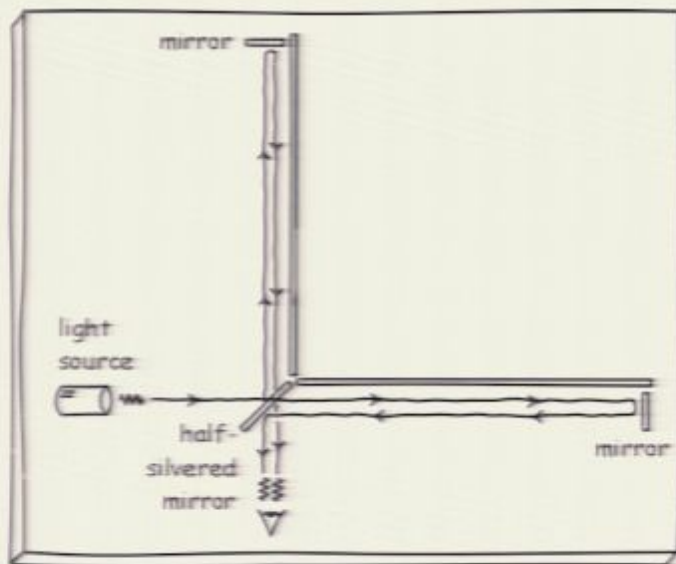
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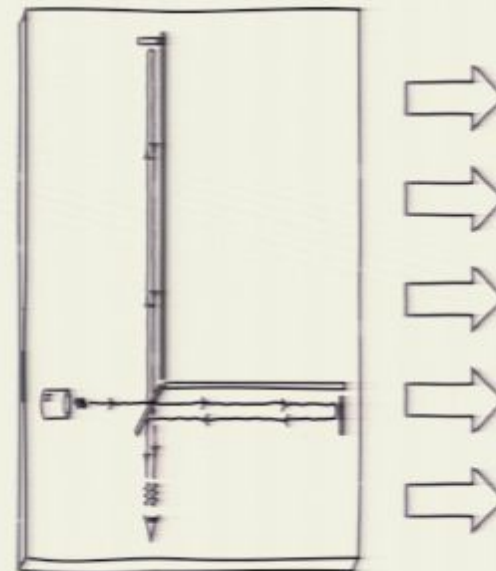
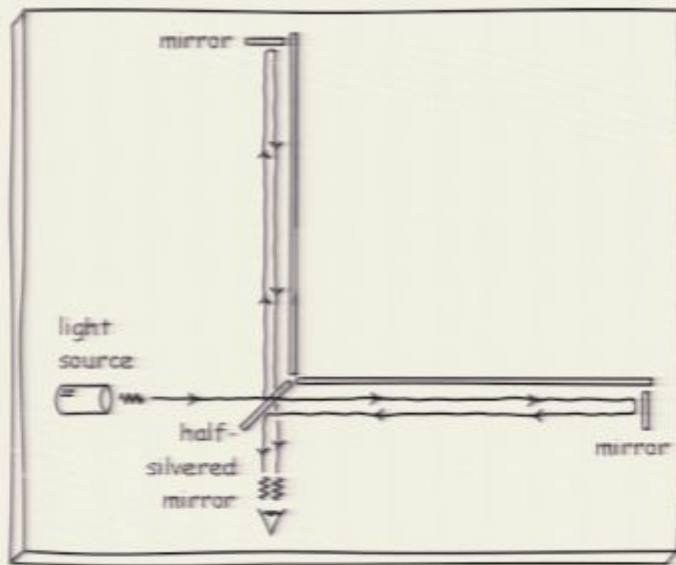
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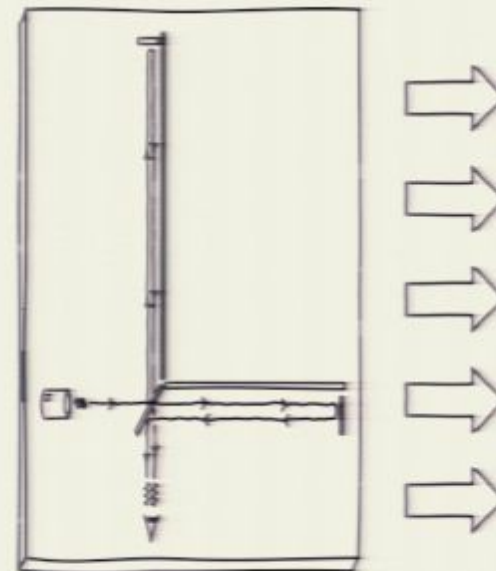
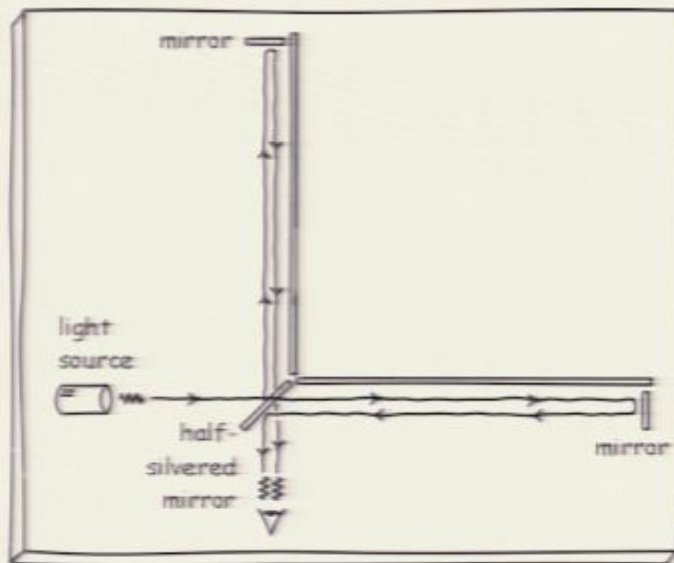
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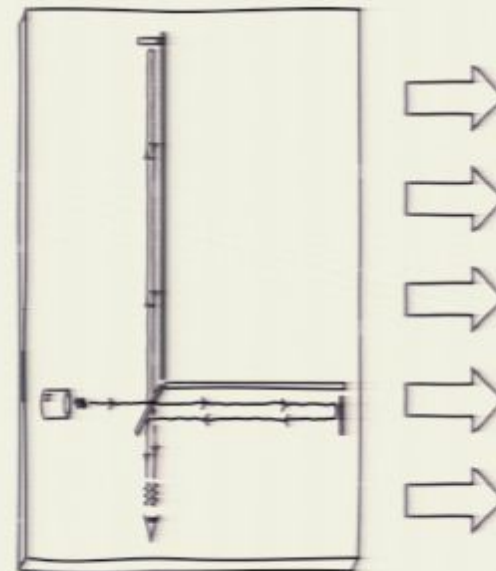
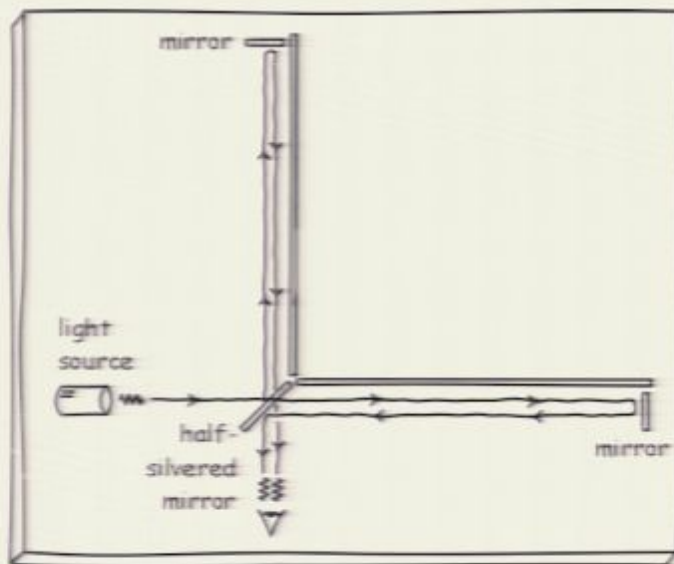
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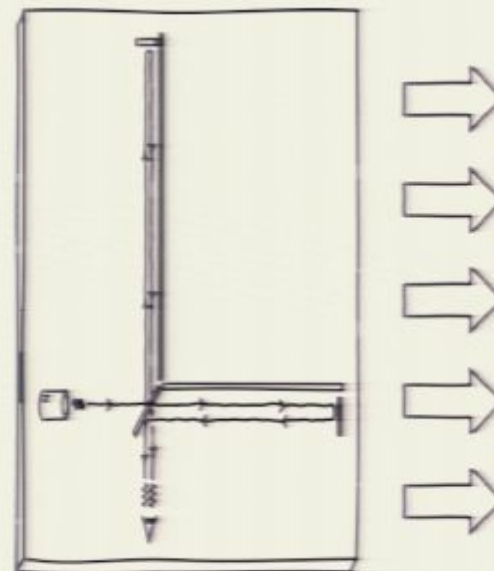
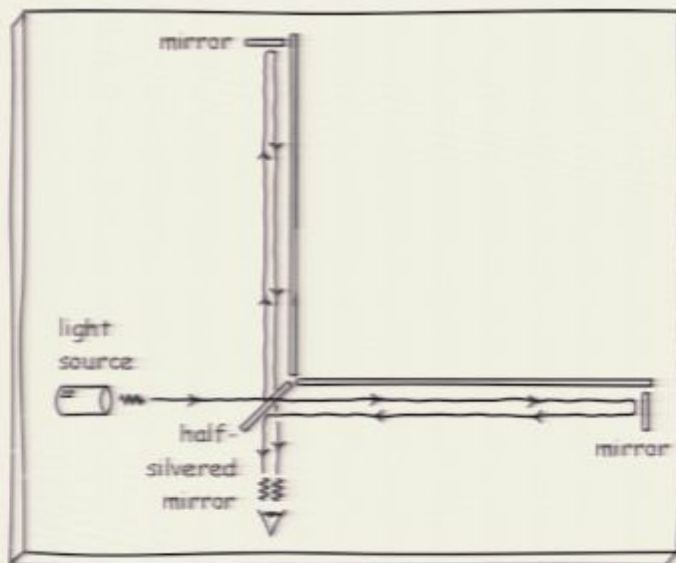
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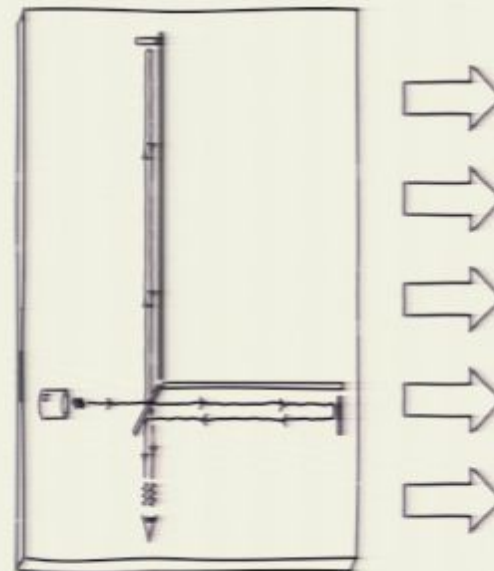
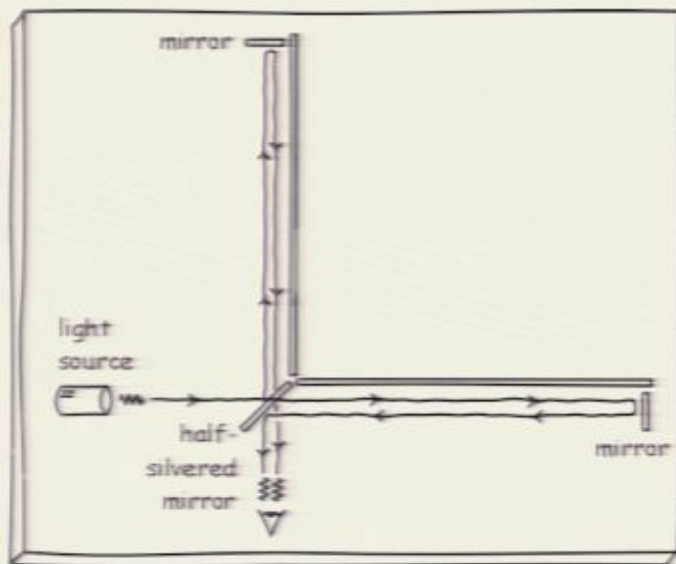
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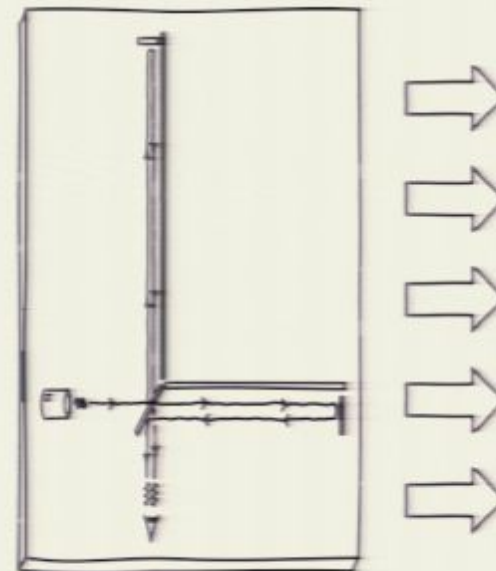
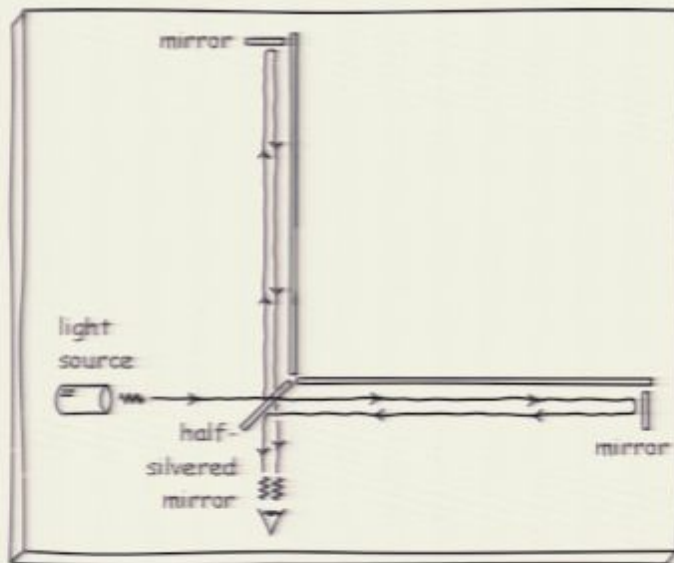
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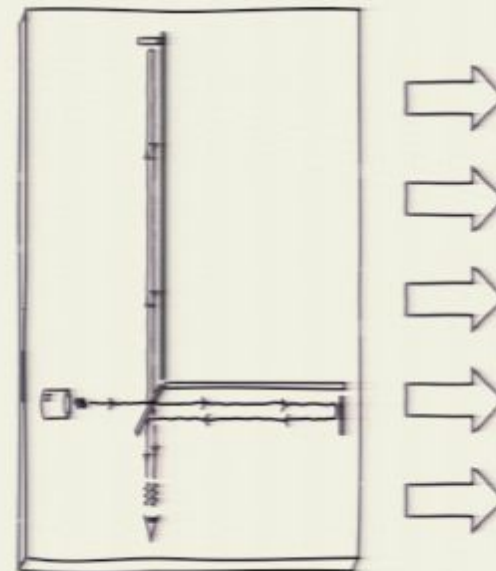
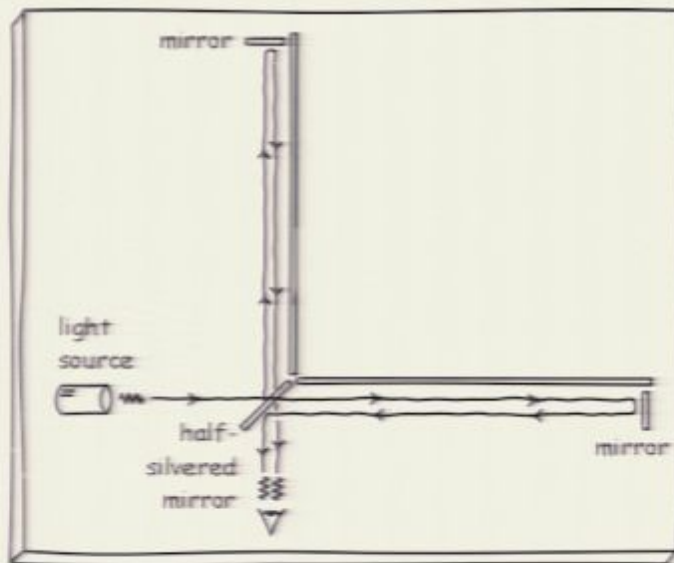
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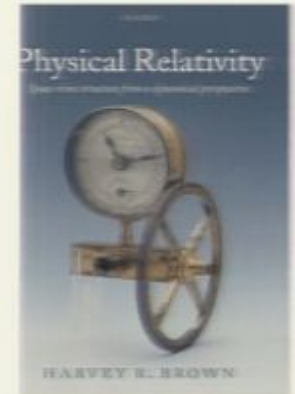
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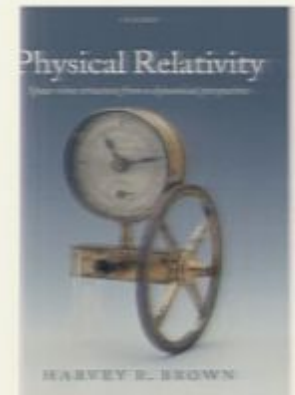


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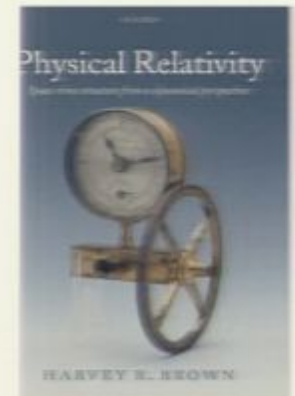


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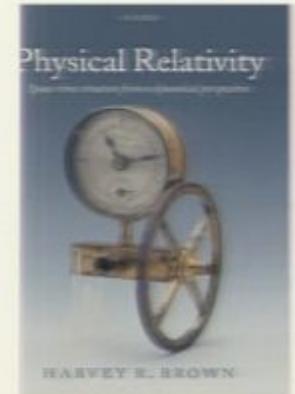


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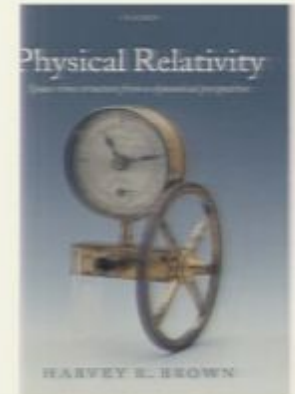


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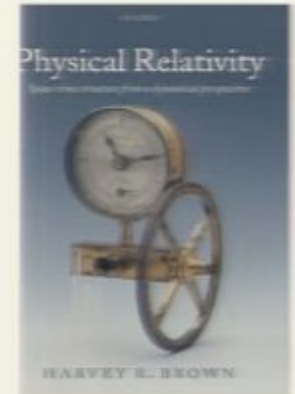


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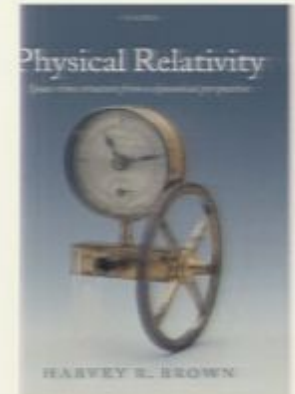


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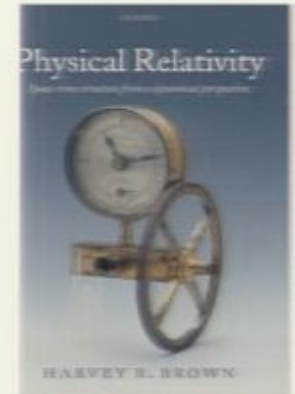


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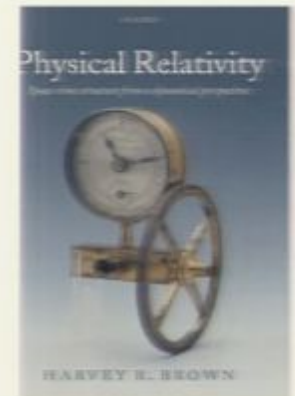


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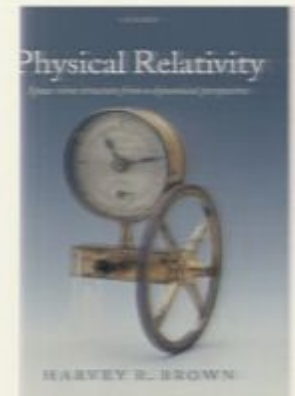


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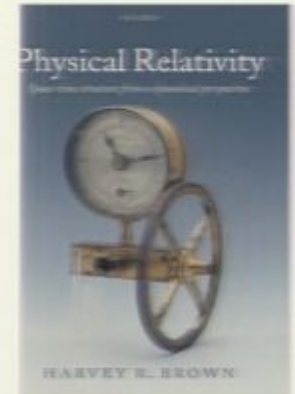


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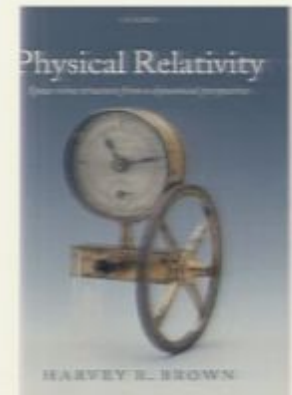


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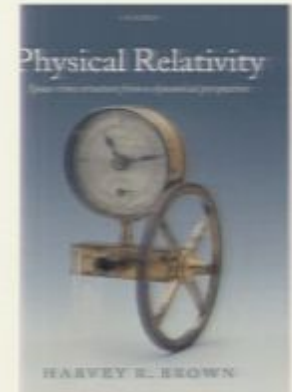
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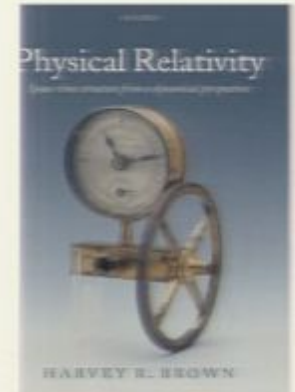
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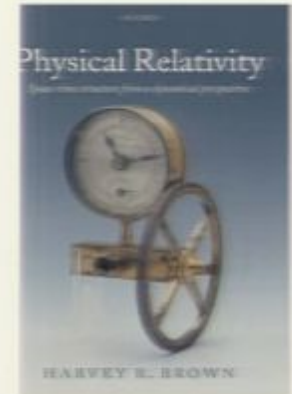
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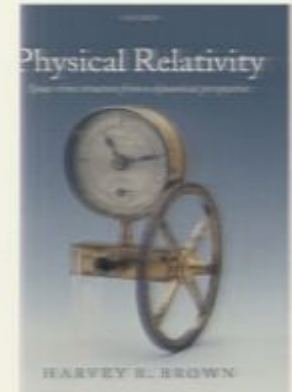
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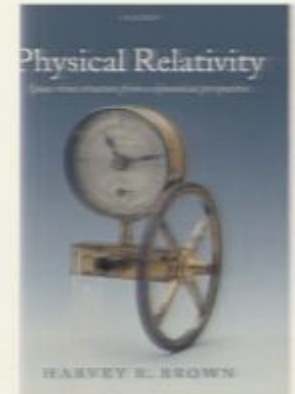
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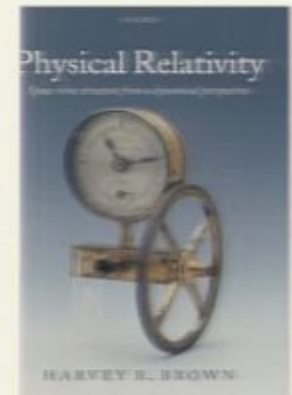
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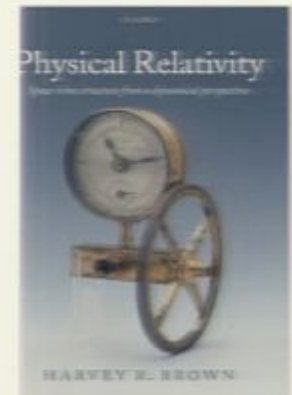
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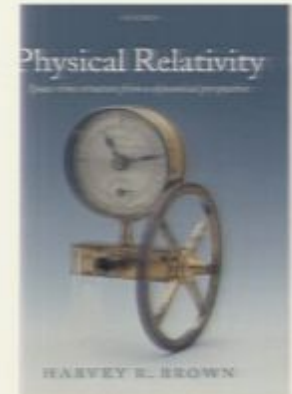
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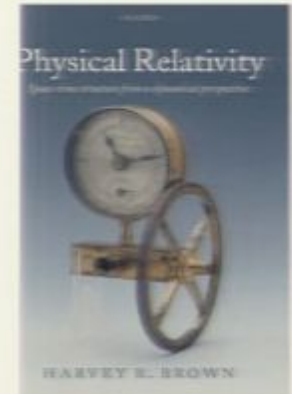
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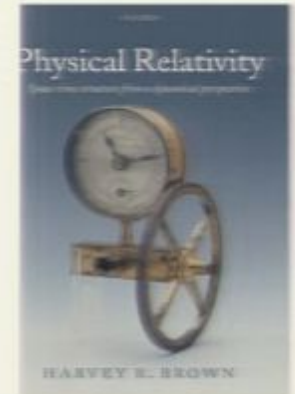
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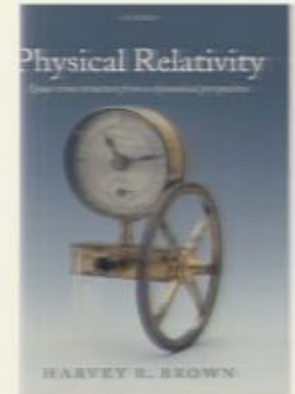
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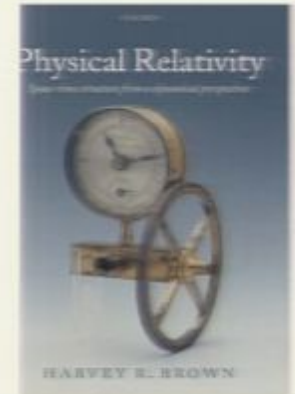
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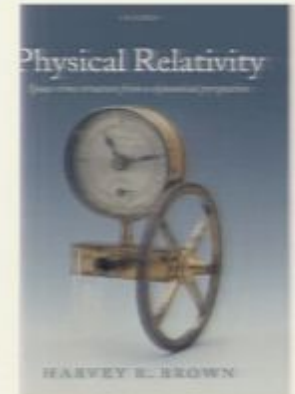
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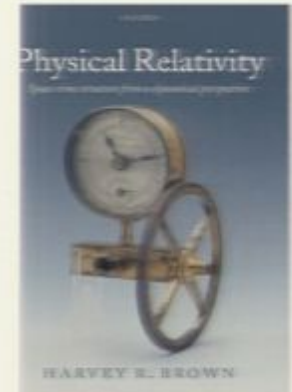
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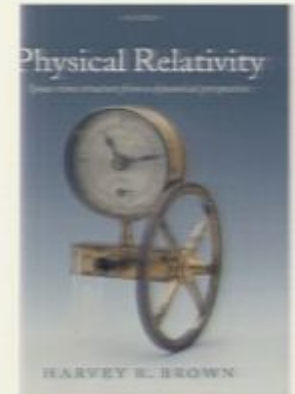
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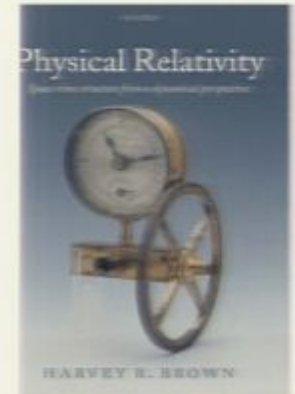
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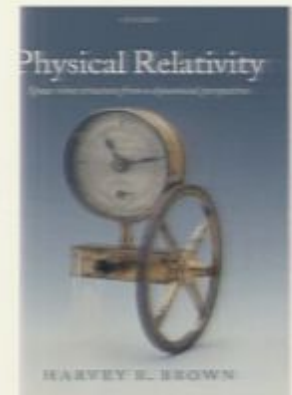
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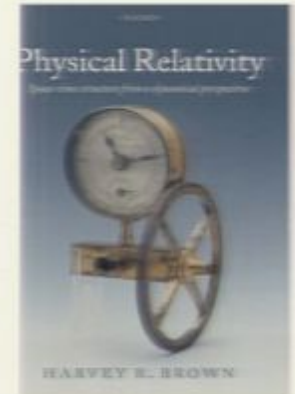
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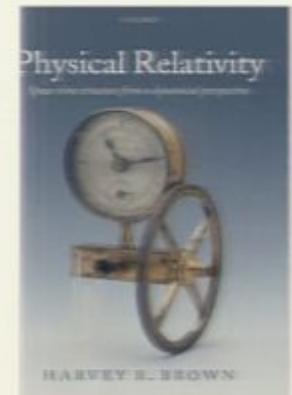
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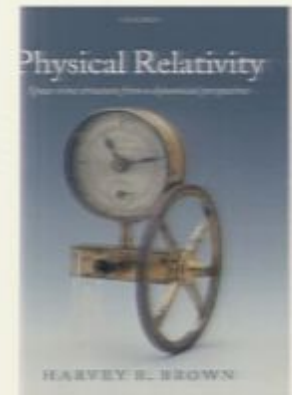
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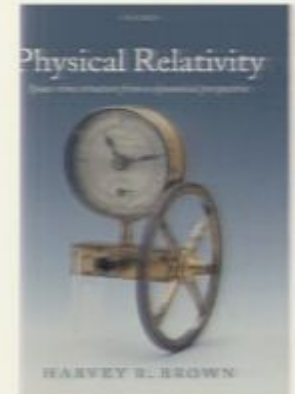
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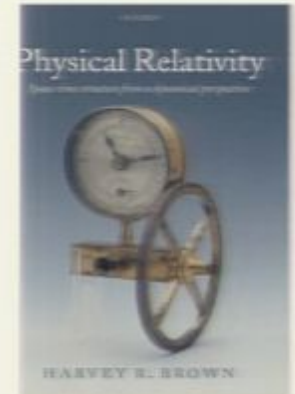
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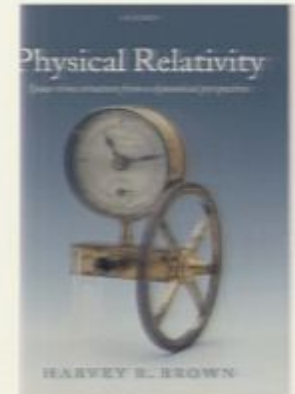


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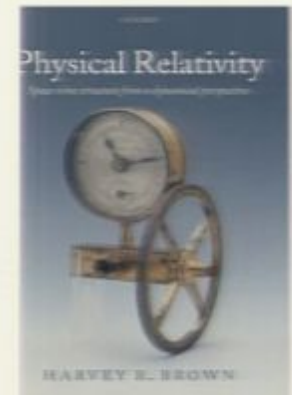


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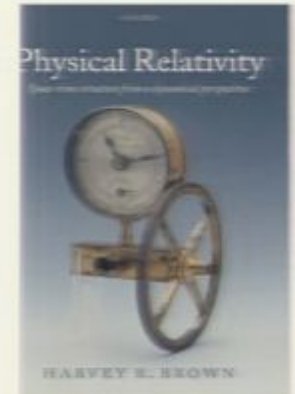


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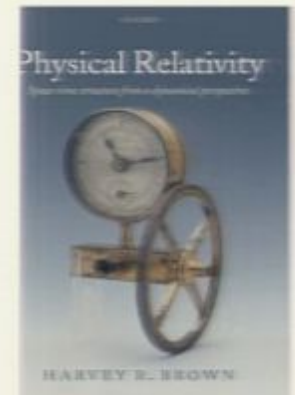


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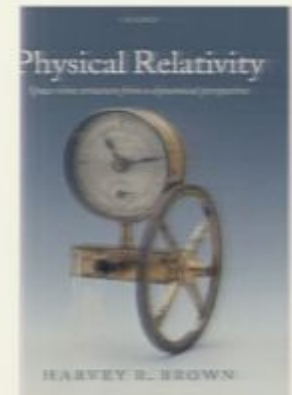


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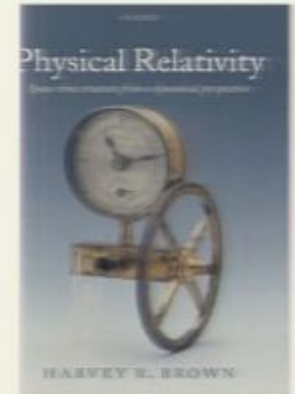


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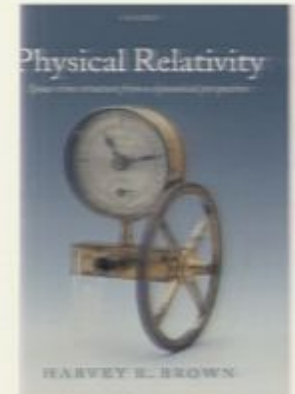


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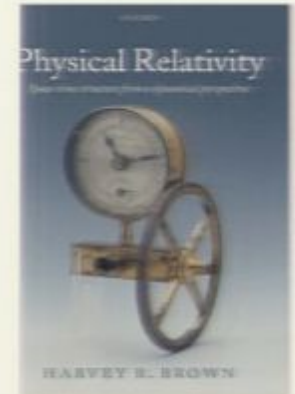


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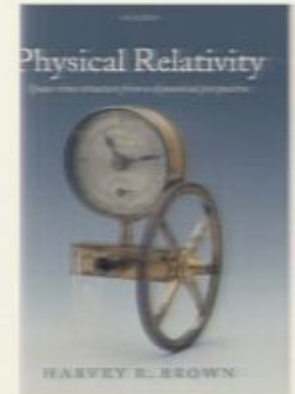


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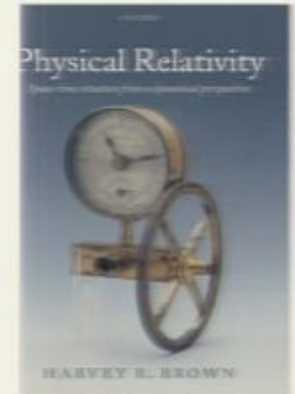


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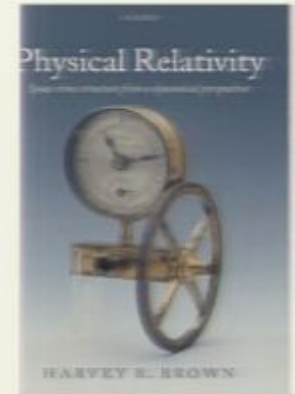


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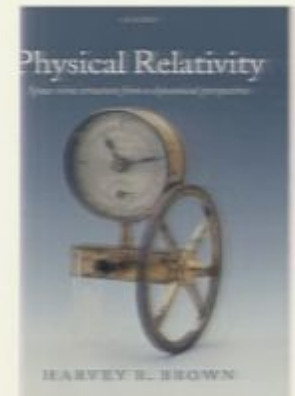


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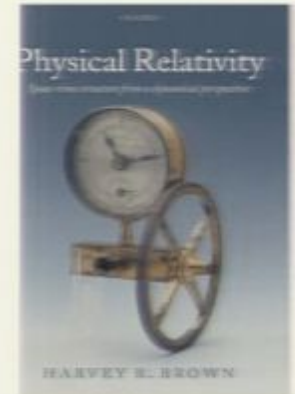


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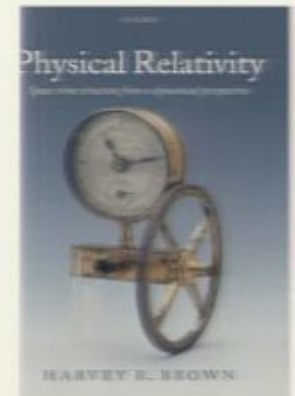


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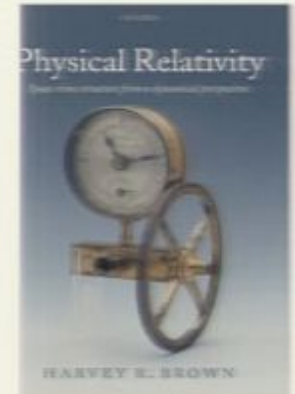


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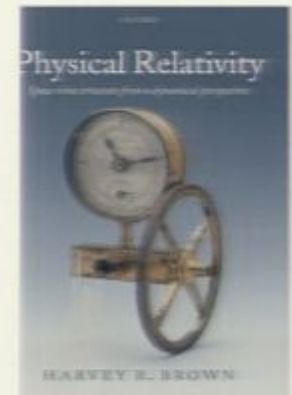


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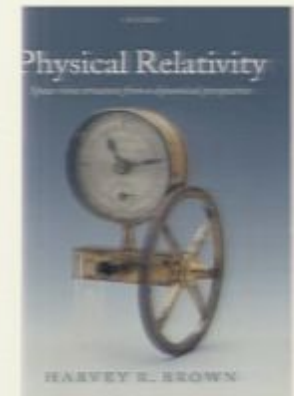
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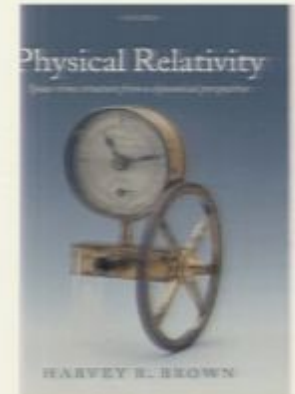
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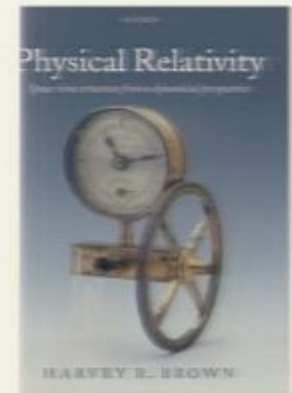
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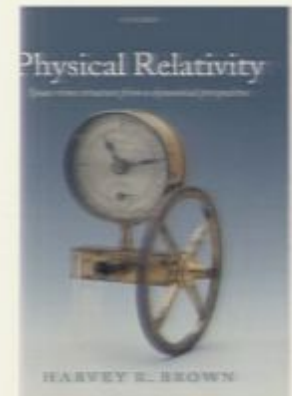
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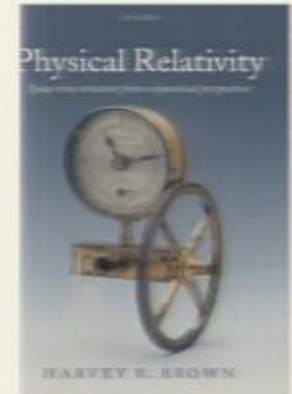
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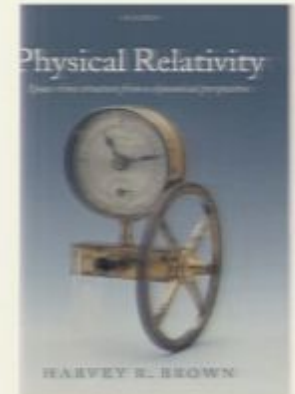
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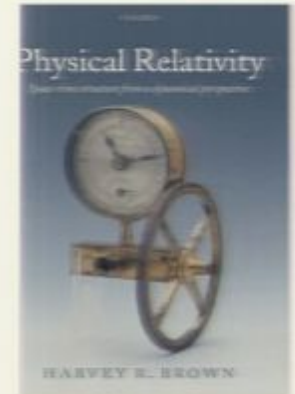
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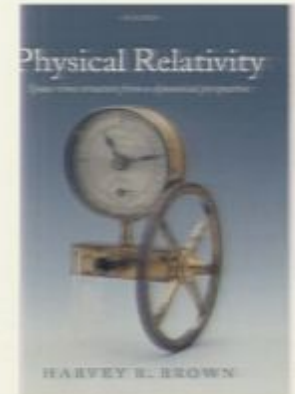
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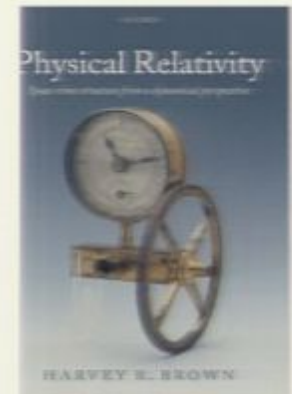
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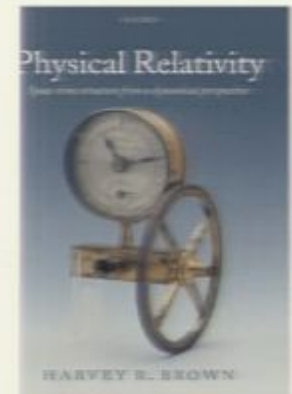
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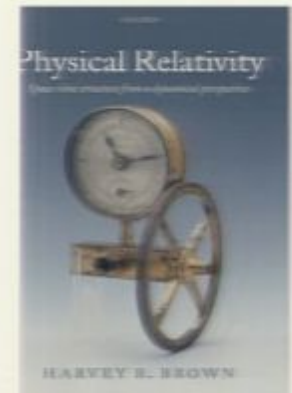
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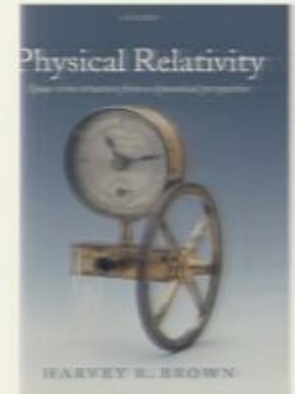
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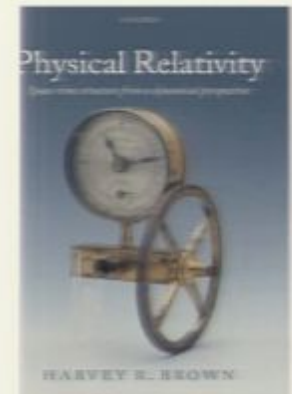
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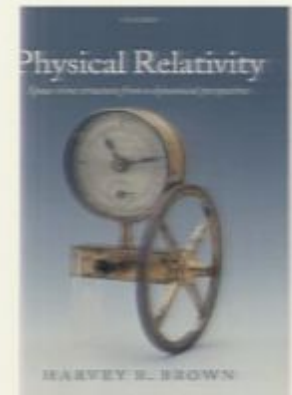
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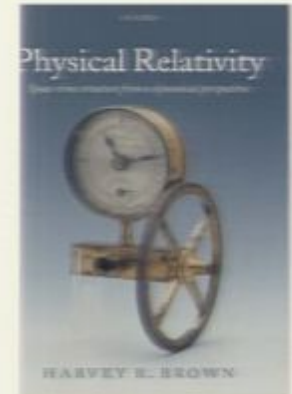
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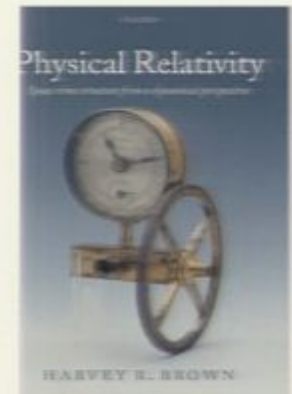
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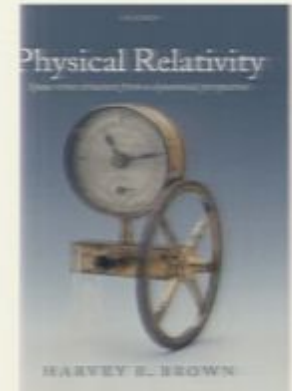
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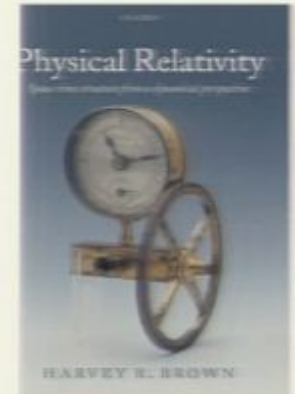
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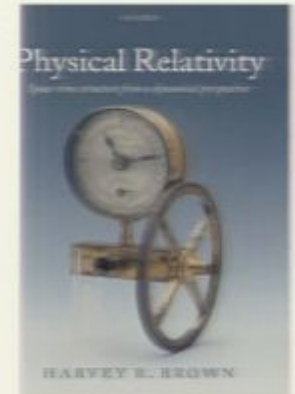
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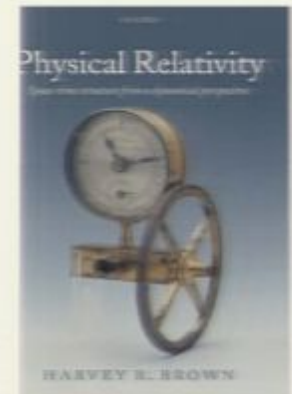
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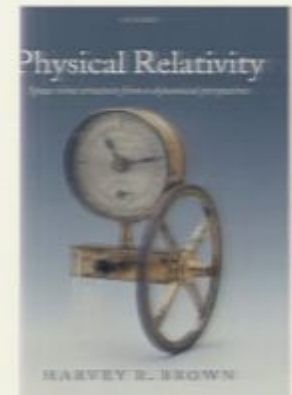
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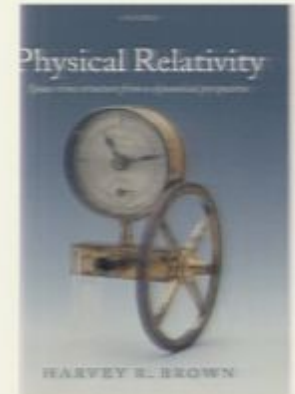
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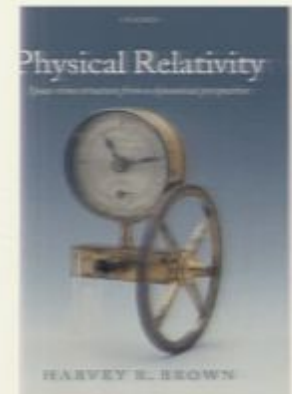
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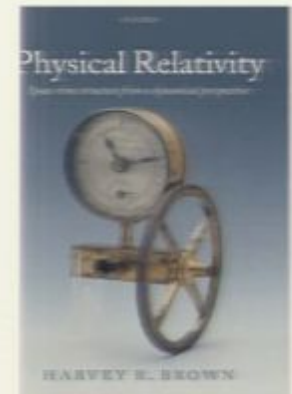
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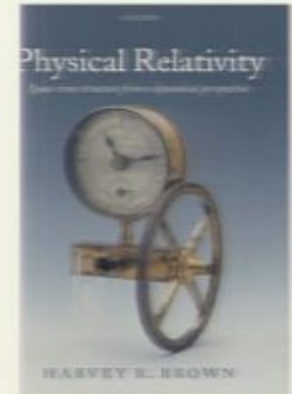
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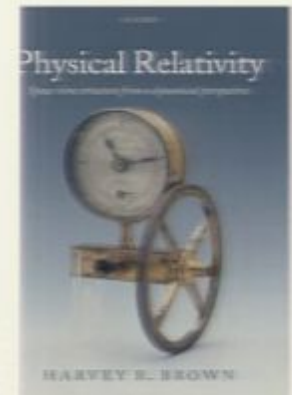
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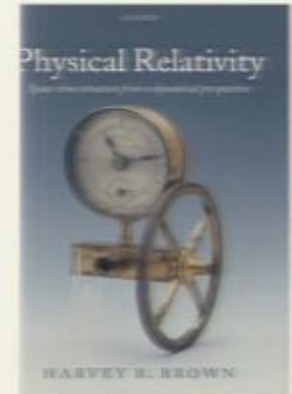
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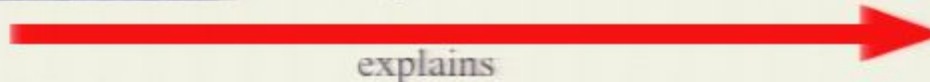
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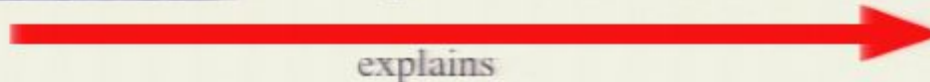
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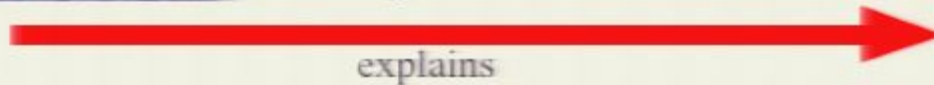
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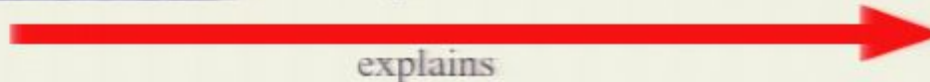
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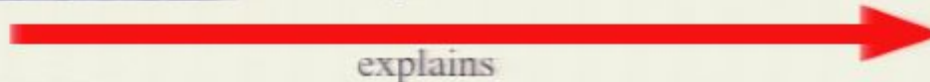
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The construction project.

A new problem for the dynamical-constructive view



The dynamical-constructive view supposes that spatiotemporal structure can be constructed (=deduced) from the properties of matter.

I argue that the construction project only succeeds in so far as it presupposes the realist view of spacetime.

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Realist's
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(a)

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Realist's
supposition
(a)

Realist's
supposition
(c)

Realist's
supposition
(b)

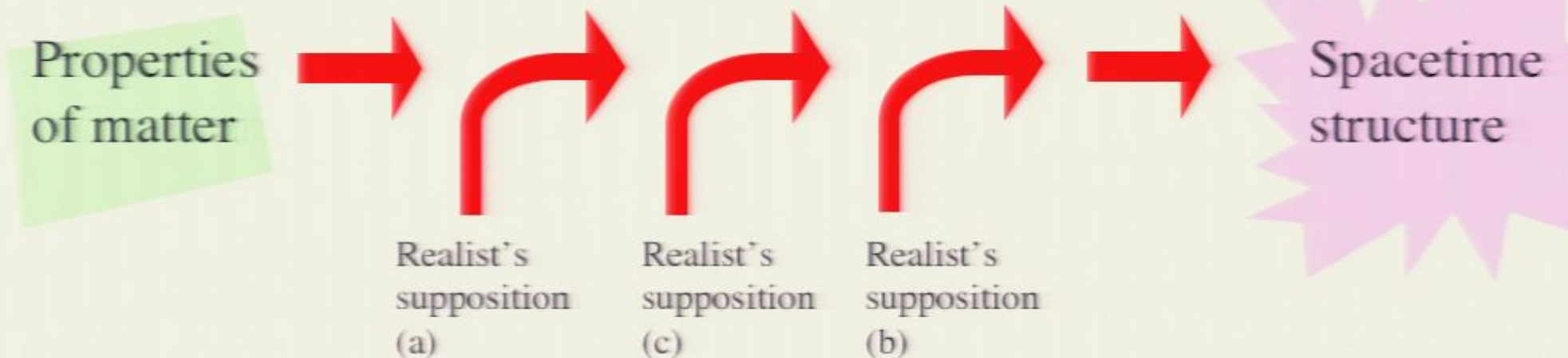


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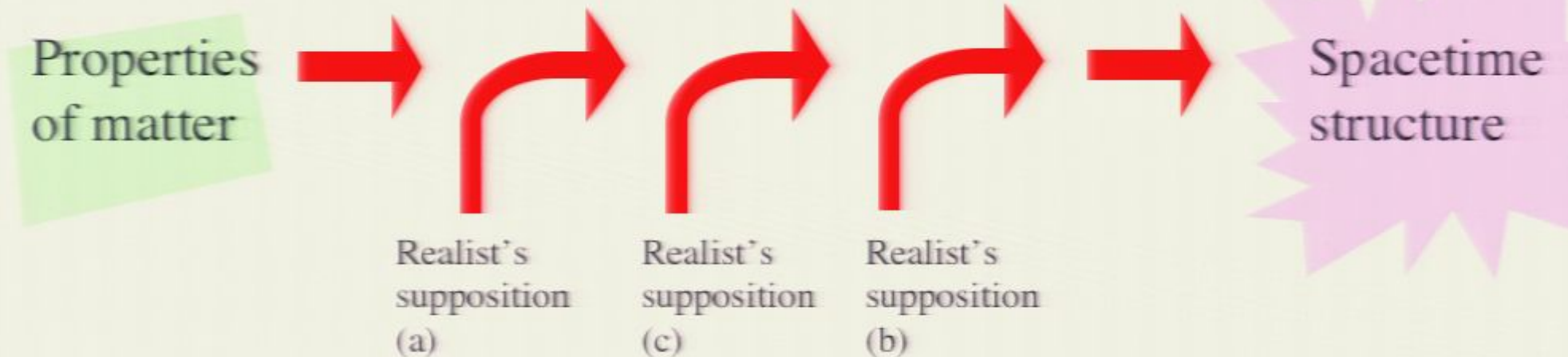
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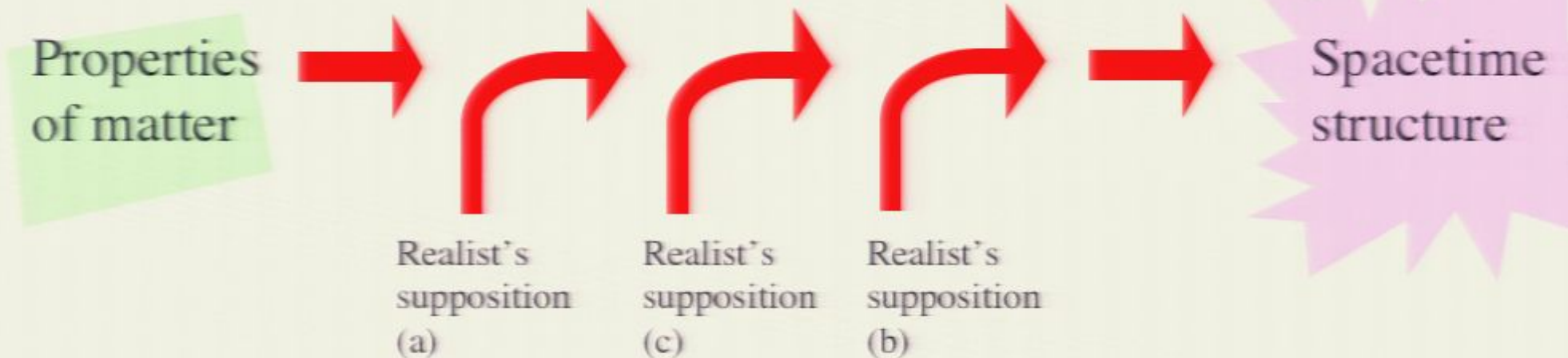
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Realist's
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(b)


Spacetime
structure

Weaker and stronger forms of the dynamical-constructive view assume more and less spacetime structure.


All either assume the realist's suppositions antecedently or tacitly during the construction project.




The Realist's Conception of a Minkowski Spacetime



The Realist's Conception of a Minkowski Spacetime

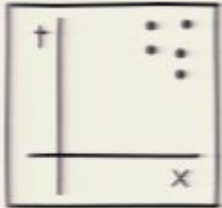


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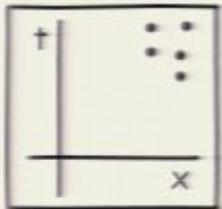
Realist's Conception



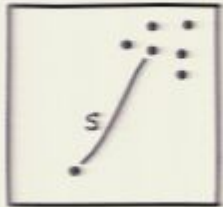
(a) There exists a four-dimensional spacetime that can be coordinatized by a set of standard coordinates (x, y, z, t) , related by the Lorentz transformation.

When $s^2 > 0$, the interval s corresponds to times elapsed on an ideal clock; when $s^2 < 0$, the interval s corresponds to spatial distances measured by ideal rods (both employed in the standard way).

Realist's Conception



(a) There exists a four-dimensional spacetime that can be coordinatized by a set of standard coordinates (x, y, z, t) , related by the Lorentz transformation.



(b) The spatiotemporal interval s between events (x, y, z, t) and (X, Y, Z, T) along a straight line connecting them is a property of the spacetime, independent of the matter it contains, and is given by

$$s^2 = (t-T)^2 - (x-X)^2 - (y-Y)^2 - (z-Z)^2$$

When $s^2 > 0$, the interval s corresponds to times elapsed on an ideal clock; when $s^2 < 0$, the interval s corresponds to spatial distances measured by ideal rods (both employed in the standard way).



(c) Material clocks and rods measure these times and distances because the laws of the matter theories that govern them are adapted to the independent geometry of this spacetime.

The problem of coincidences

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One spacetime coordinate system or many sets of parameters?

Matter theory 1: x_1, y_1, z_1, t_1

Matter theory 2: x_2, y_2, z_2, t_2

How do we know that these two sets of parameters refer to the SAME point-event in spacetime?

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Is Matter theory 1 the SAME Matter theory 2 ?
 $x_1=0, y_1=0, z_1=0, t_1=0$ point-event as $x_2=0, y_2=0, z_2=0, t_2=0$

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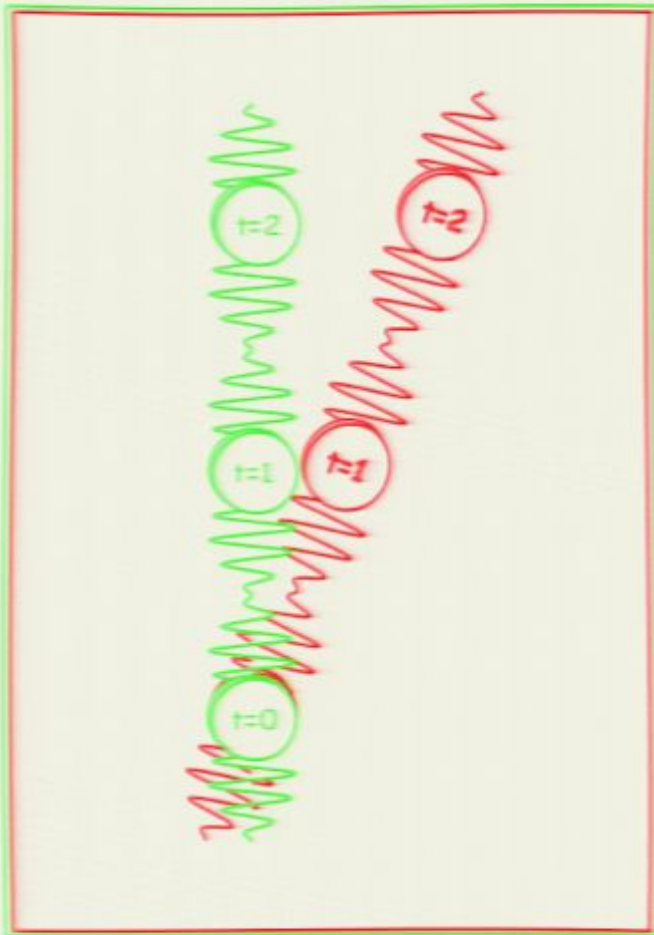
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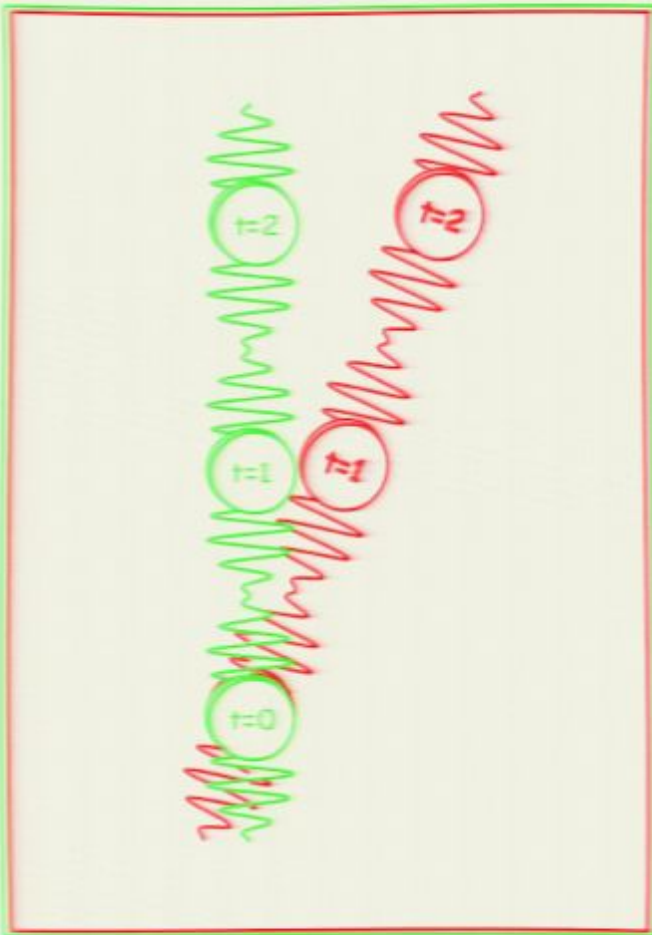
Do clocks of matter theory 1 and matter theory 2...

... map out the same space.



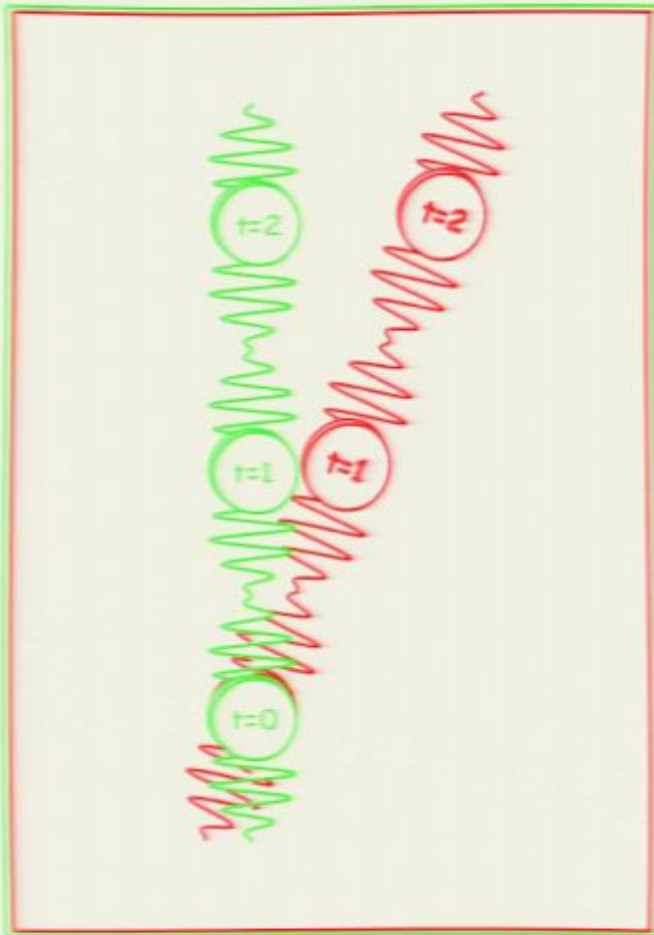
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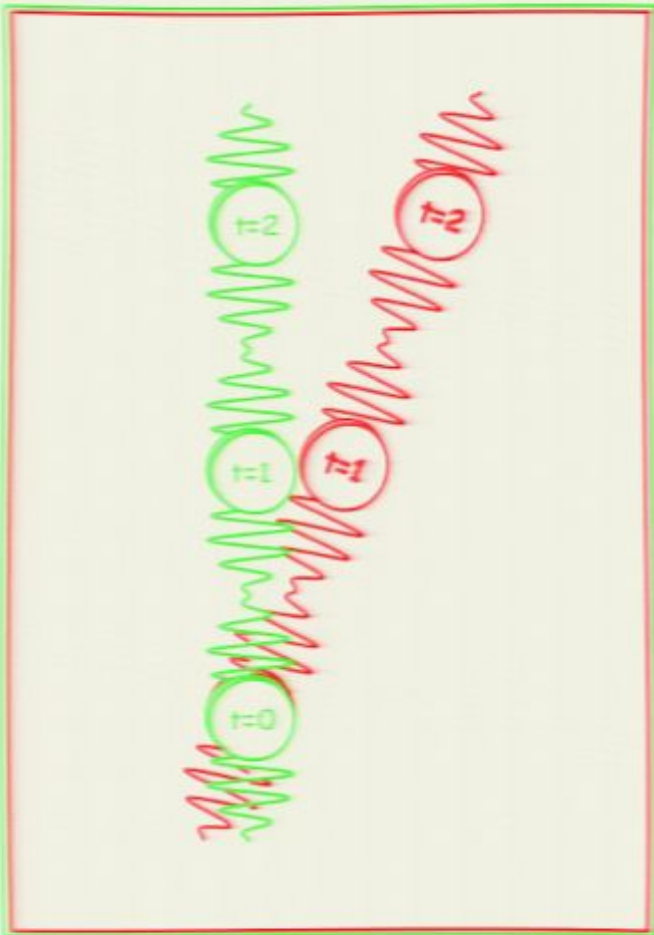
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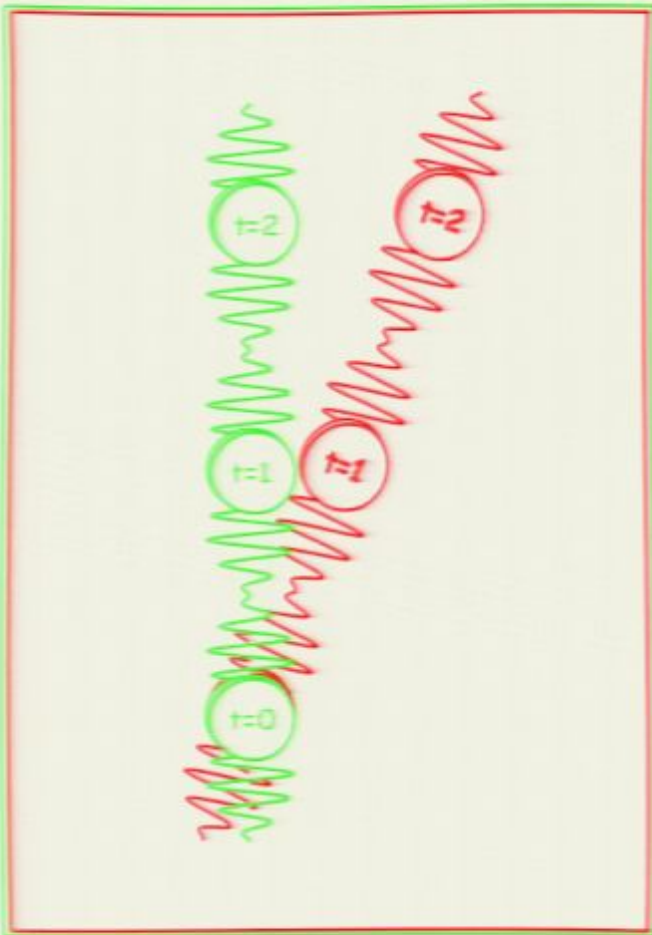
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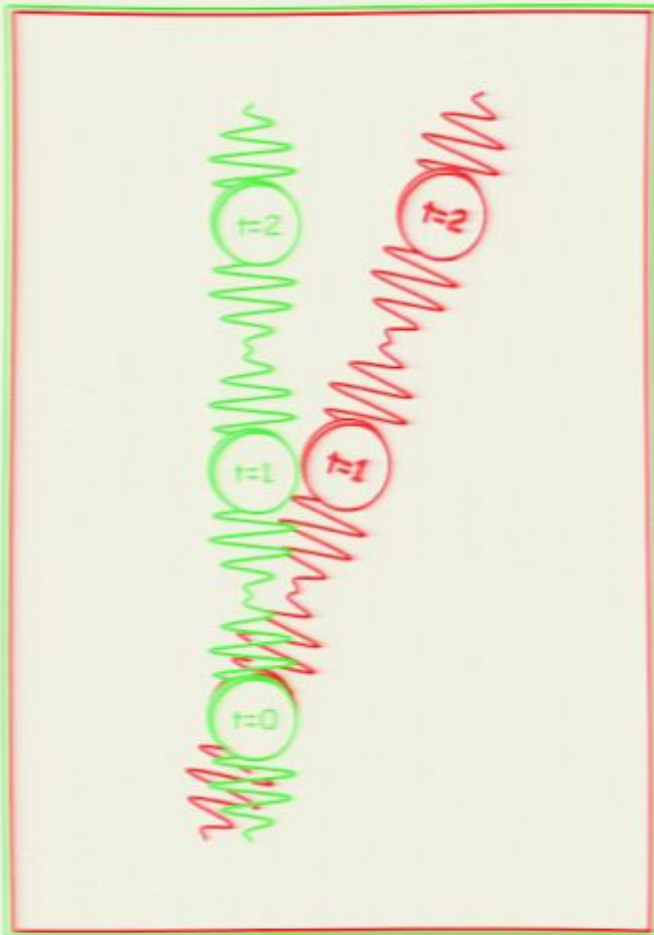
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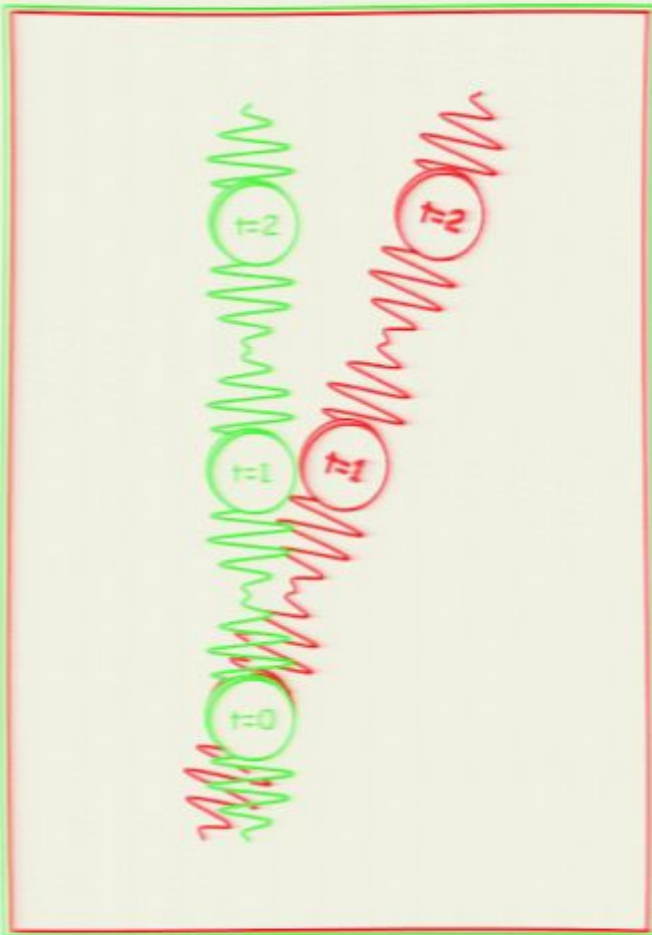
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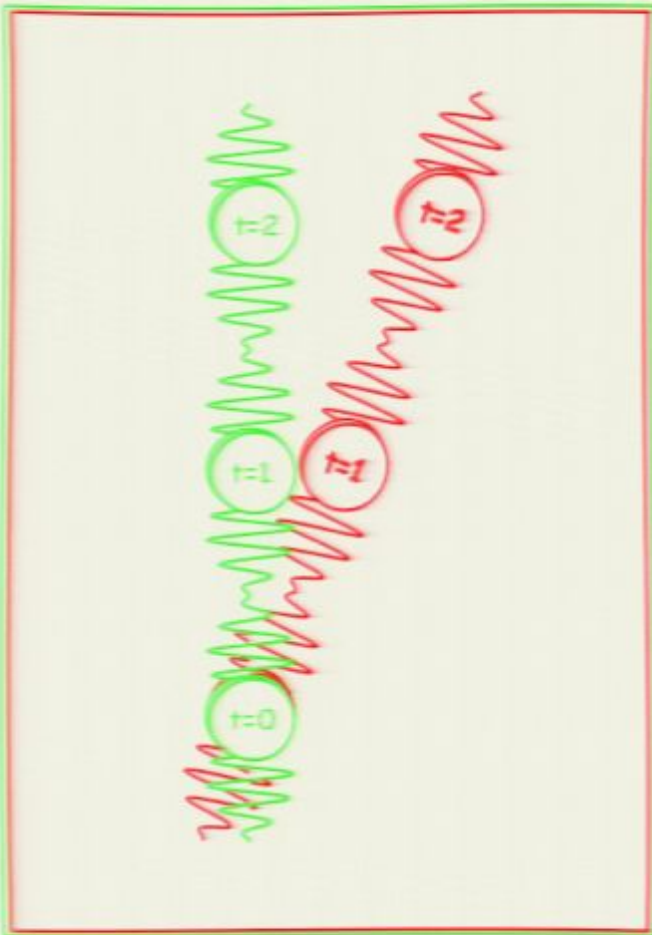
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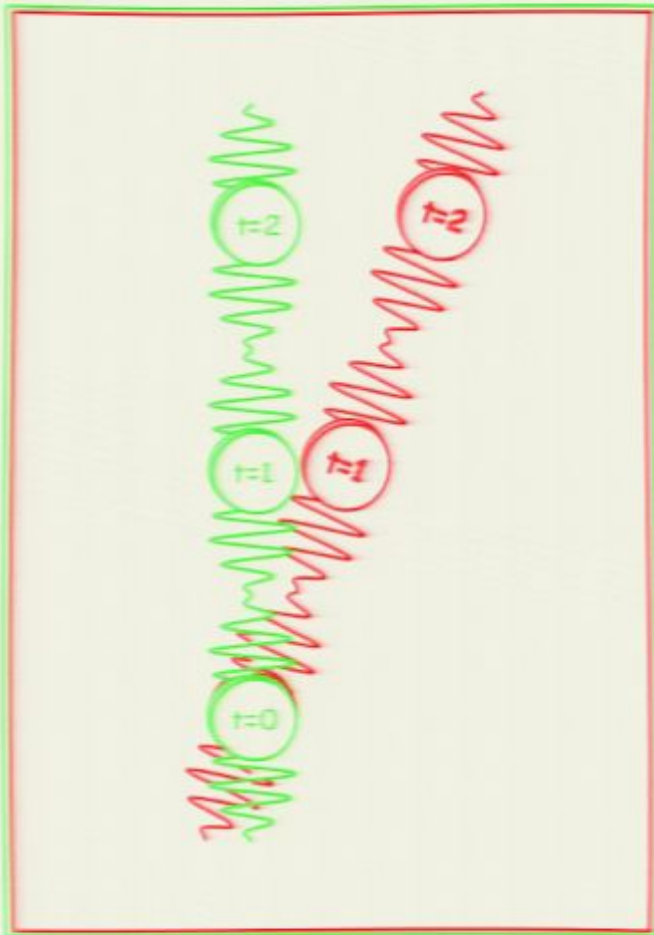
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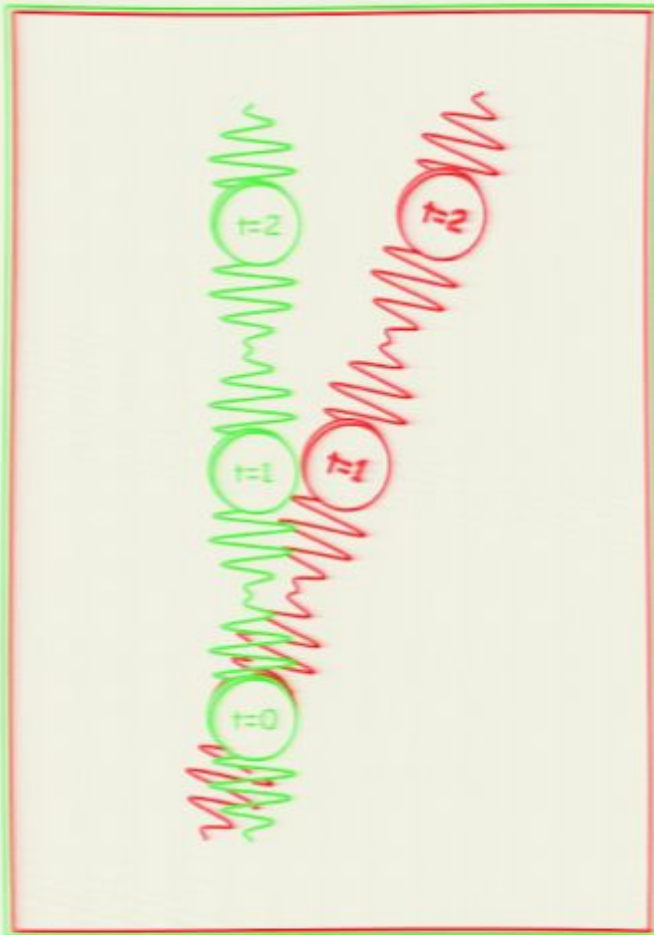
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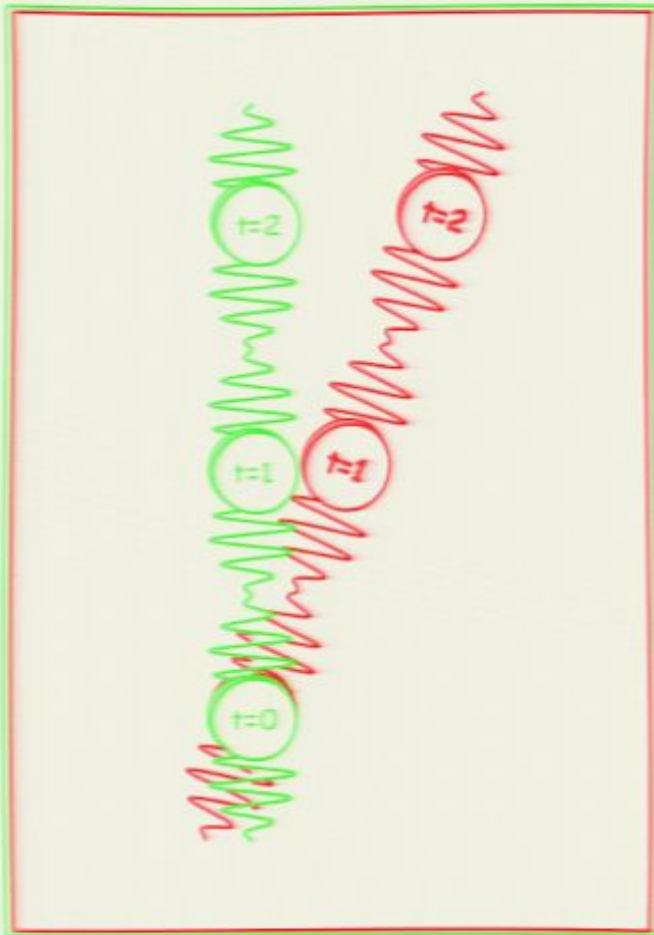
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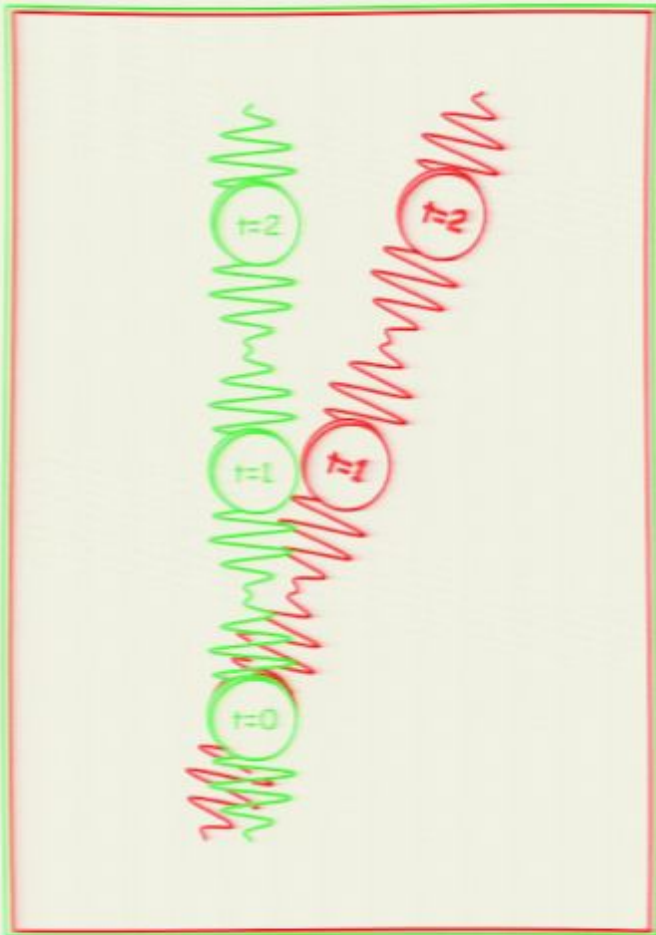
Do clocks of matter theory 1 and matter theory 2...

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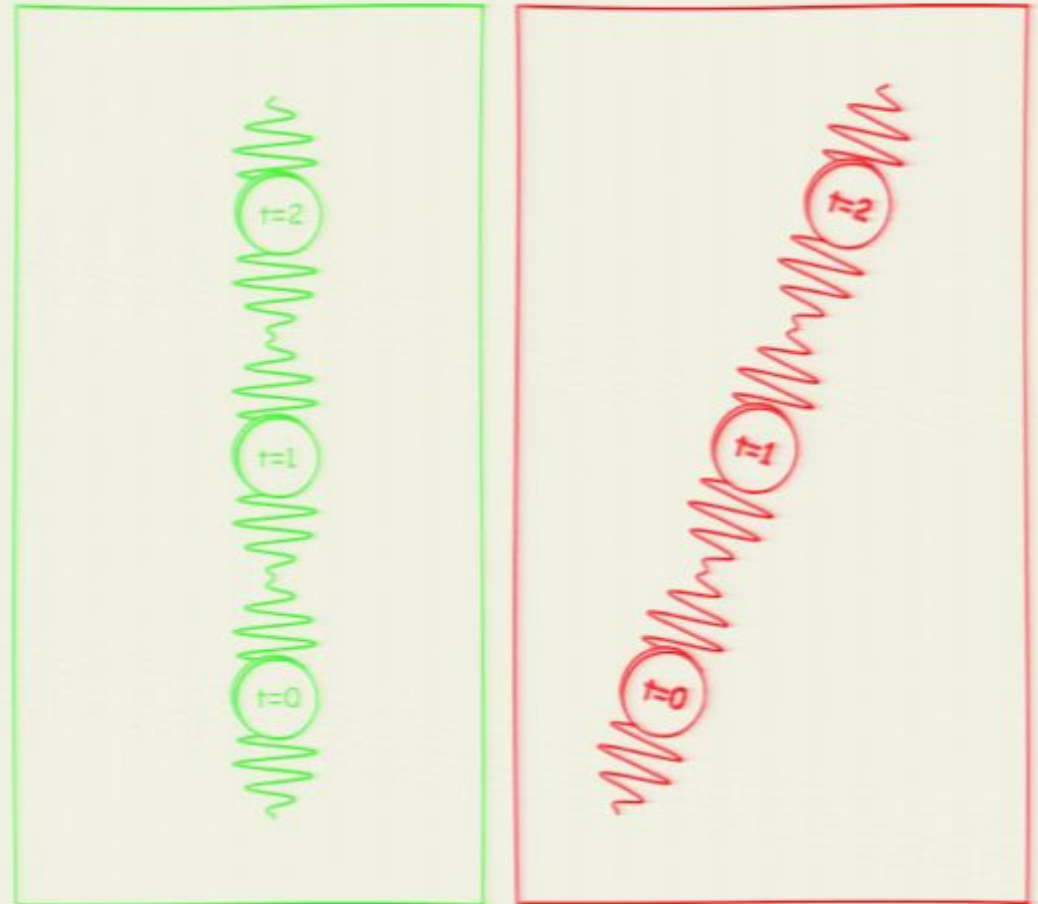


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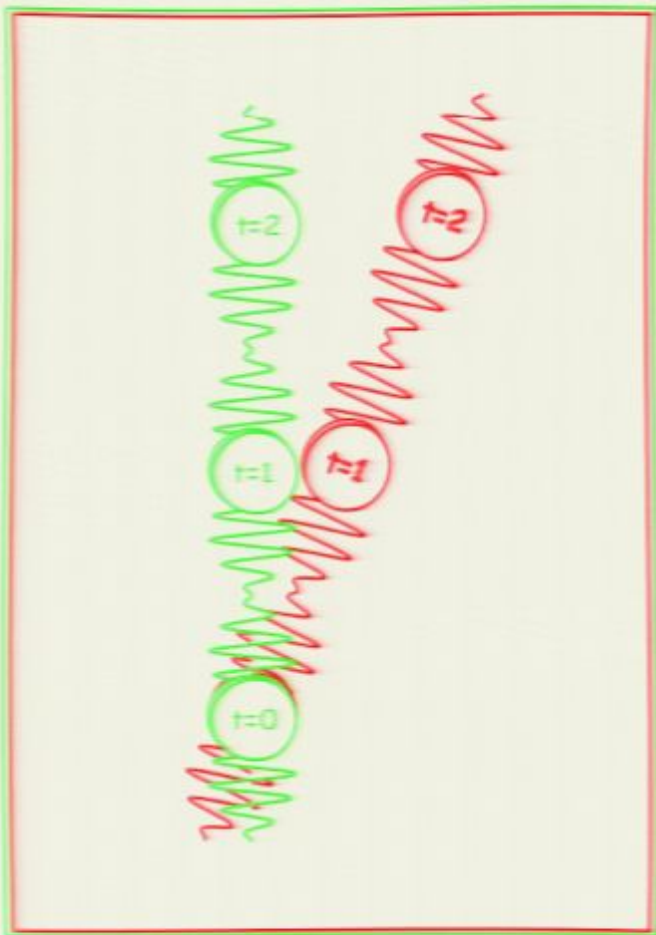


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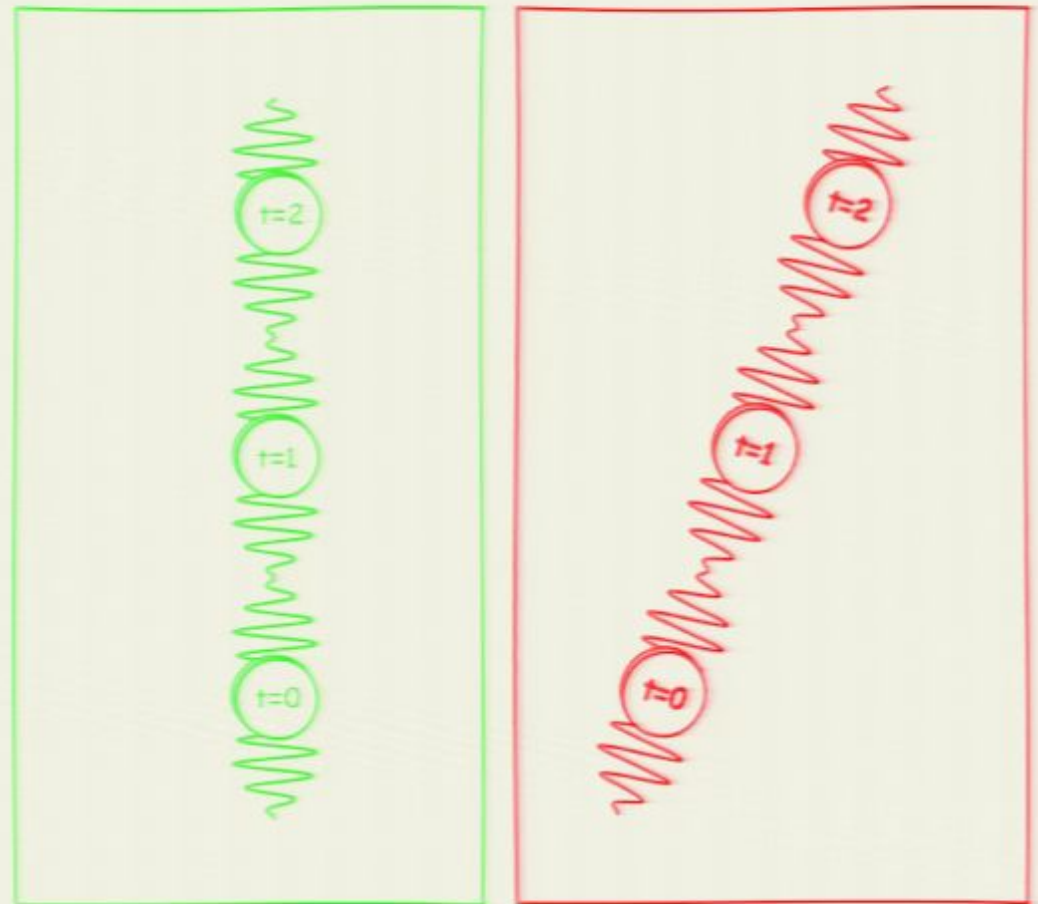


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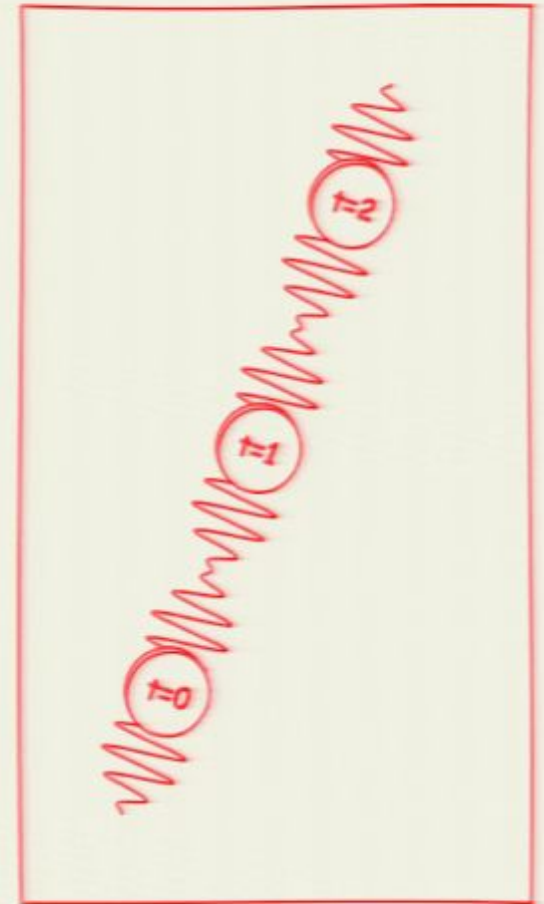
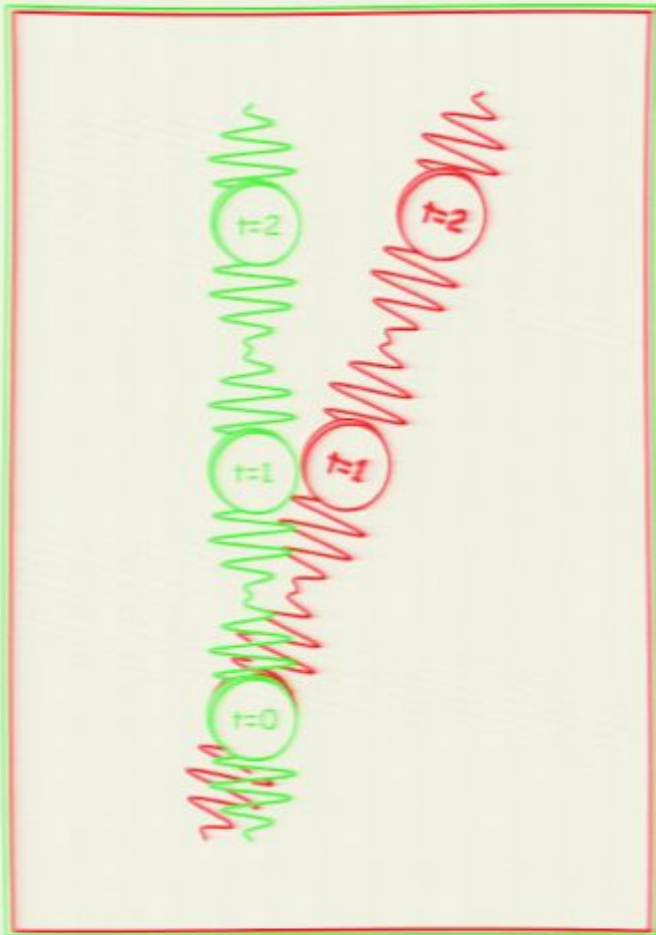
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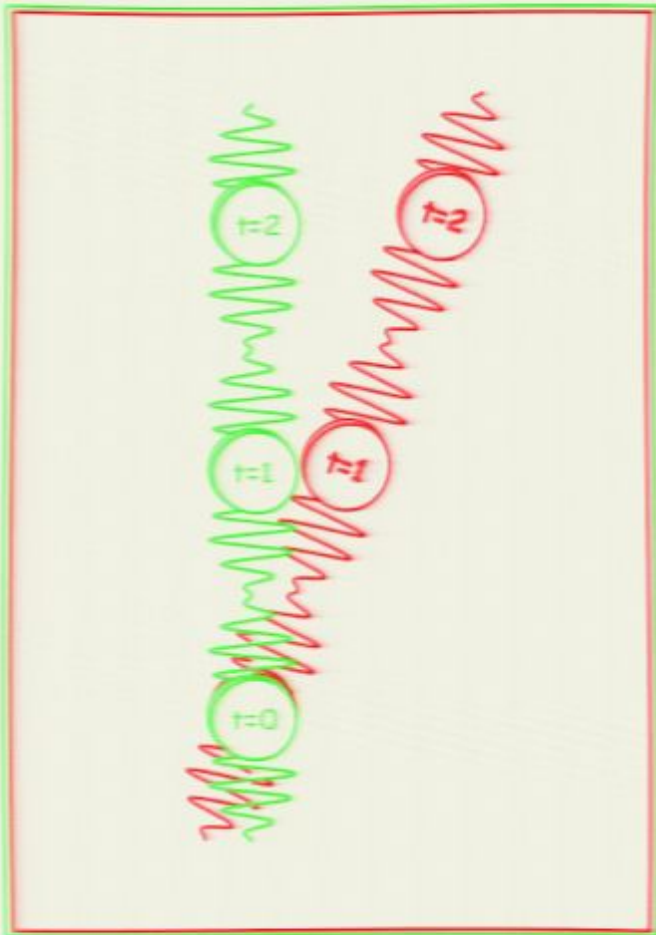
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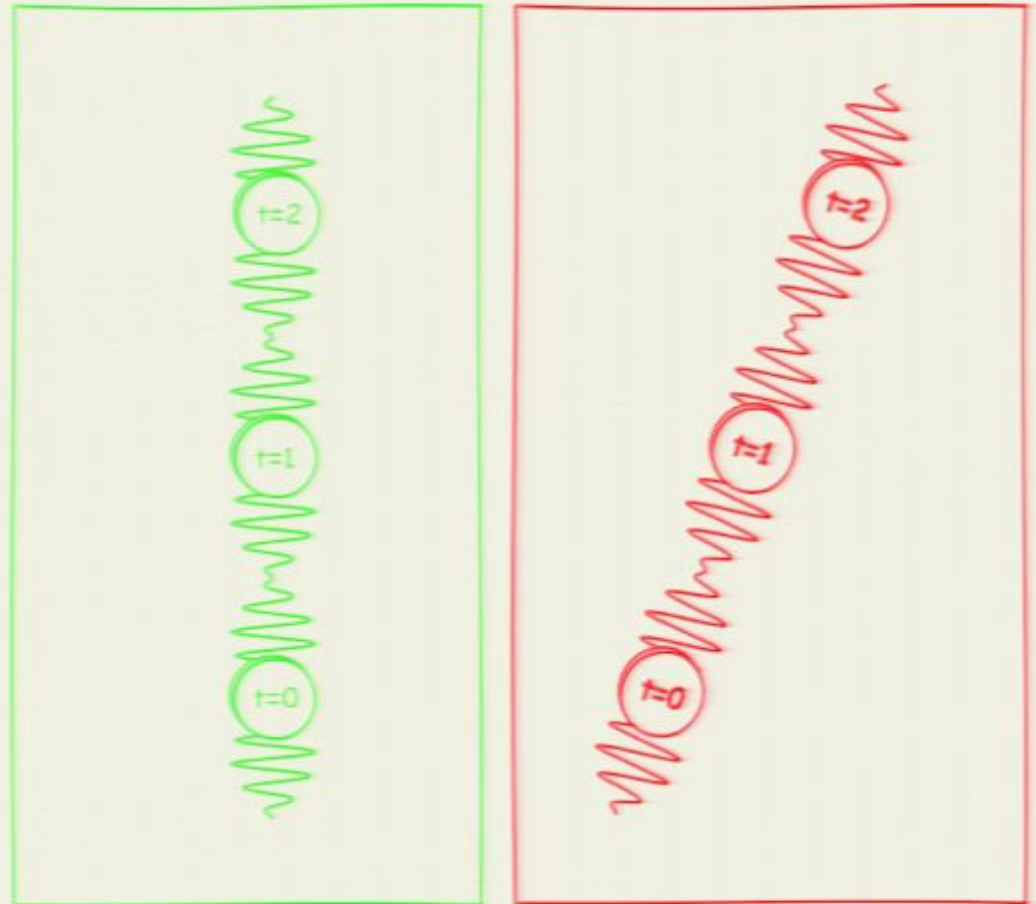


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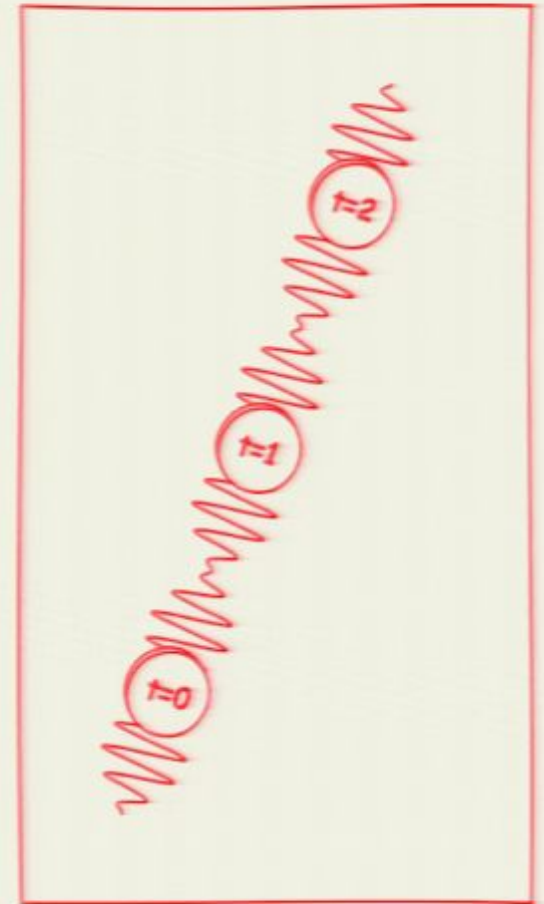
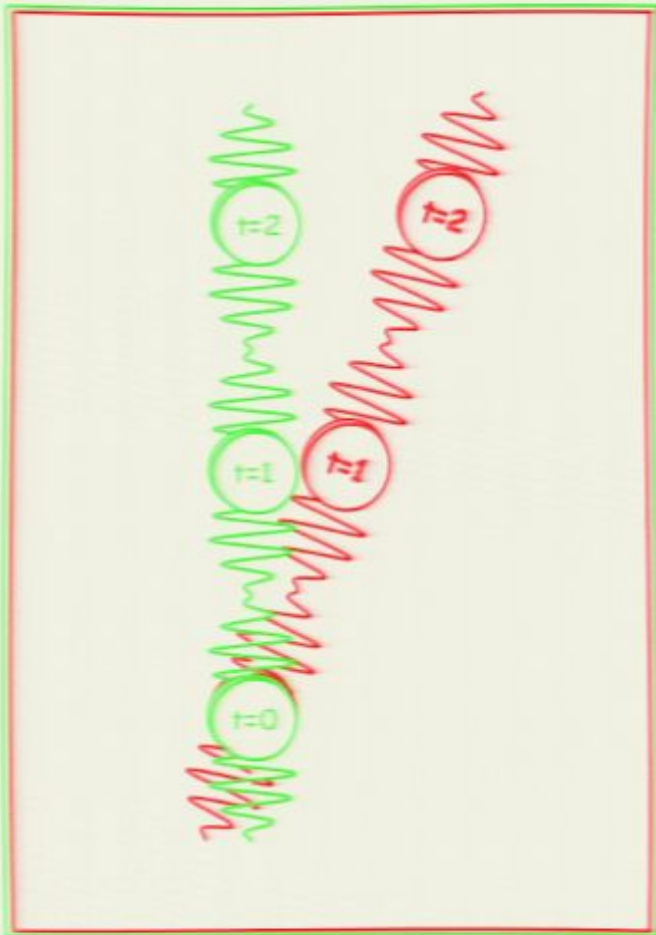
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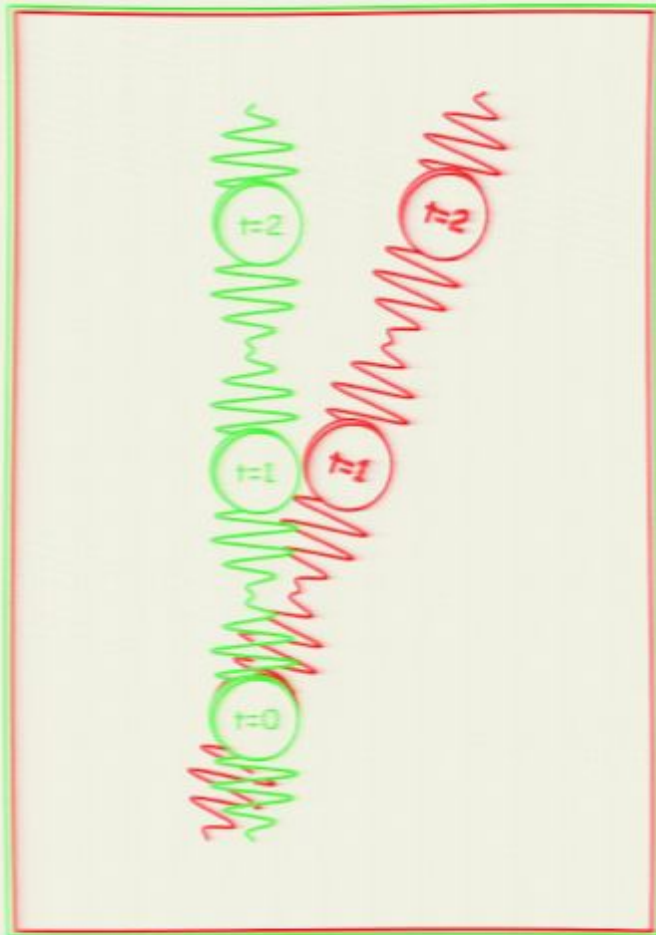
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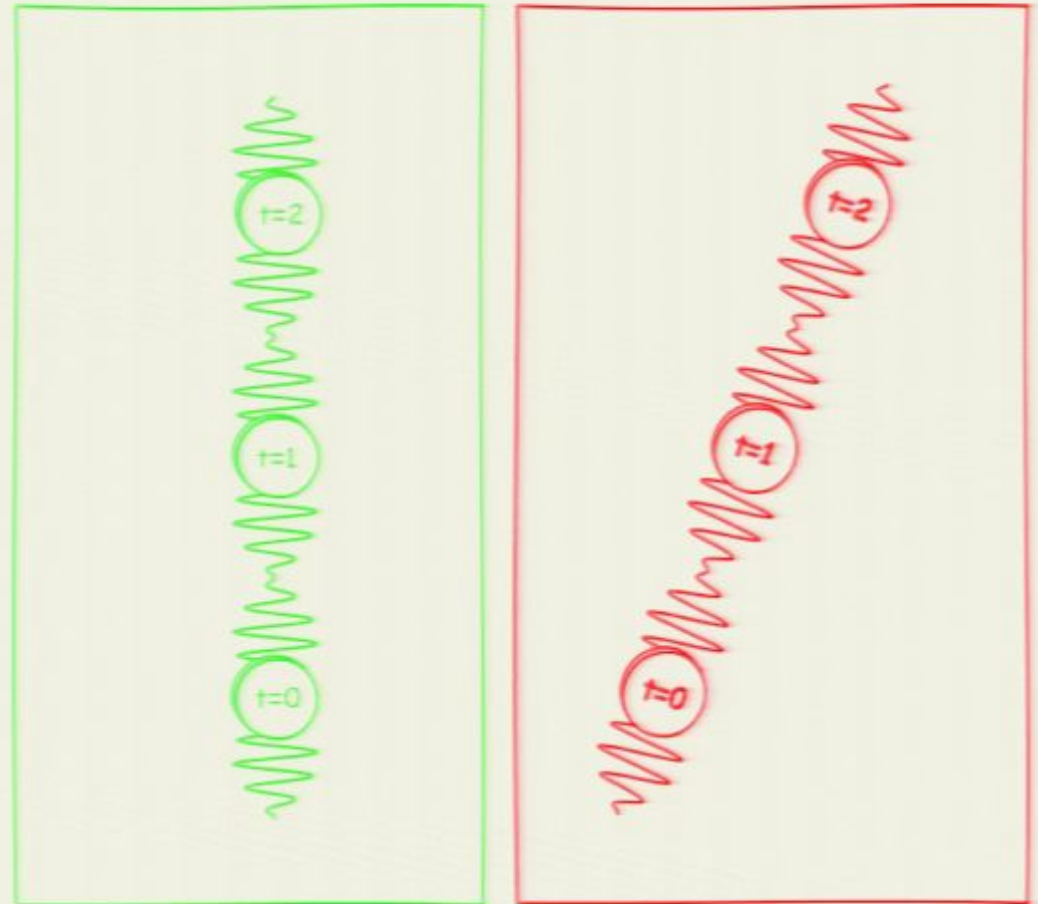


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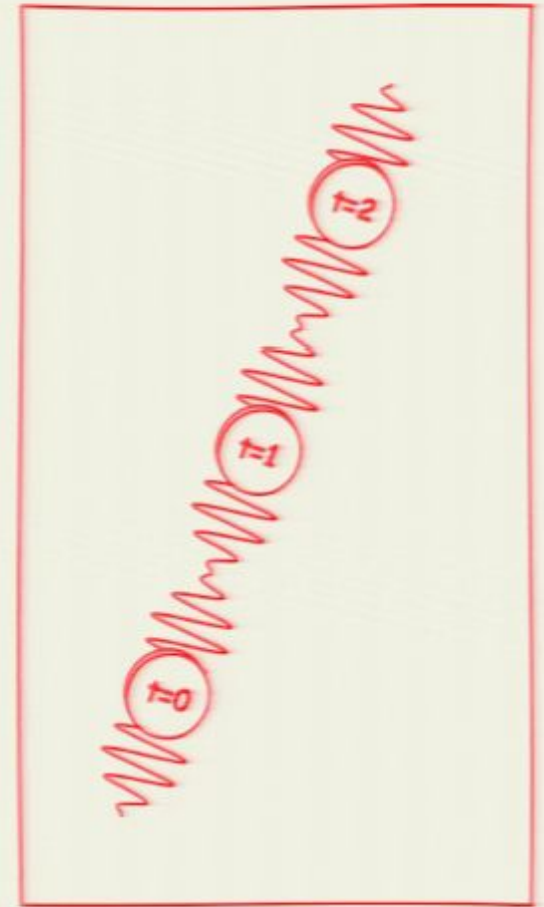
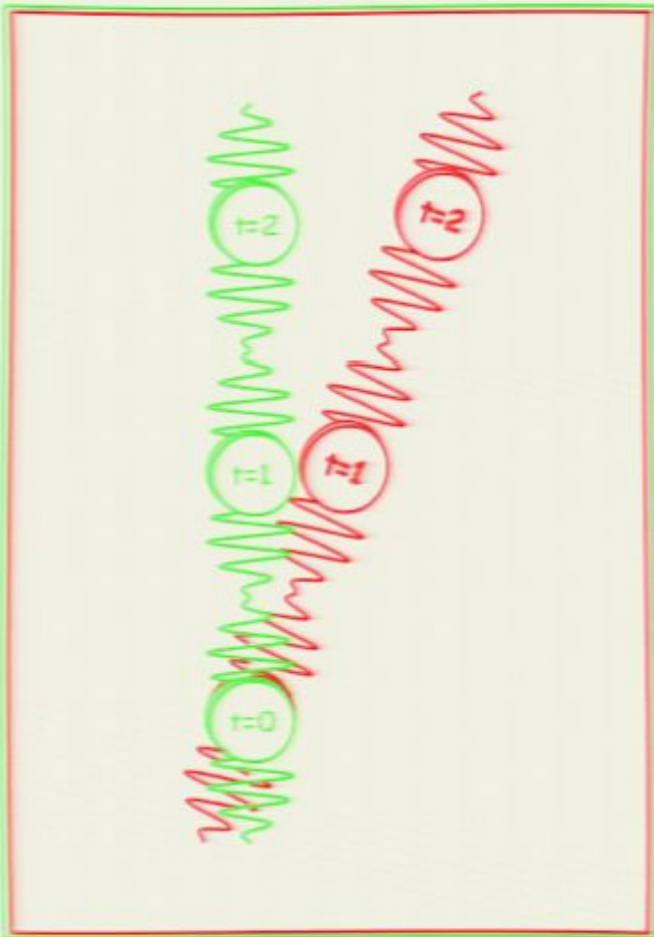
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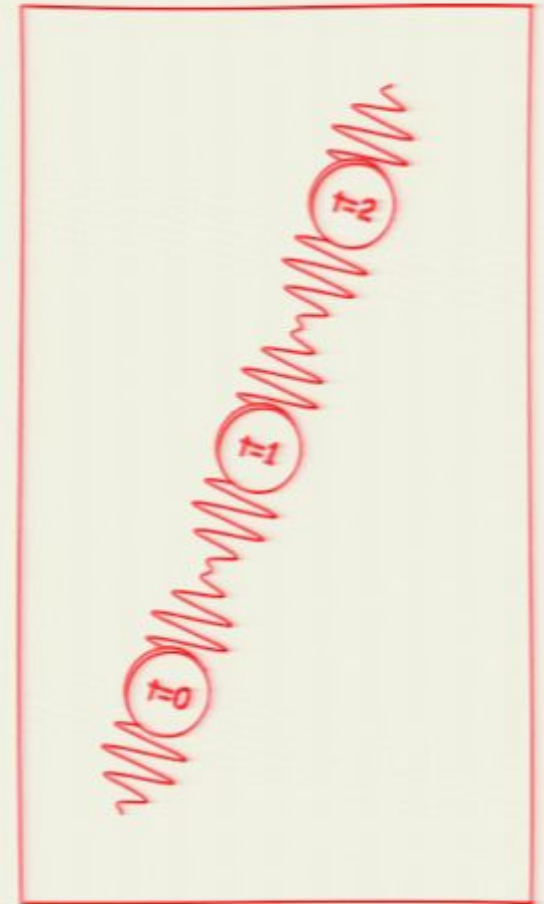
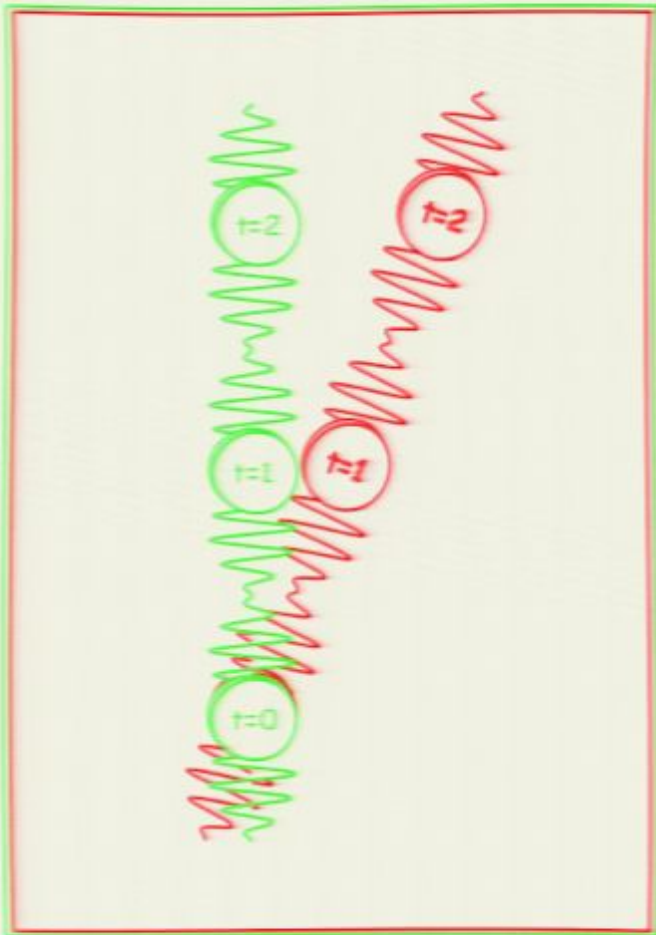
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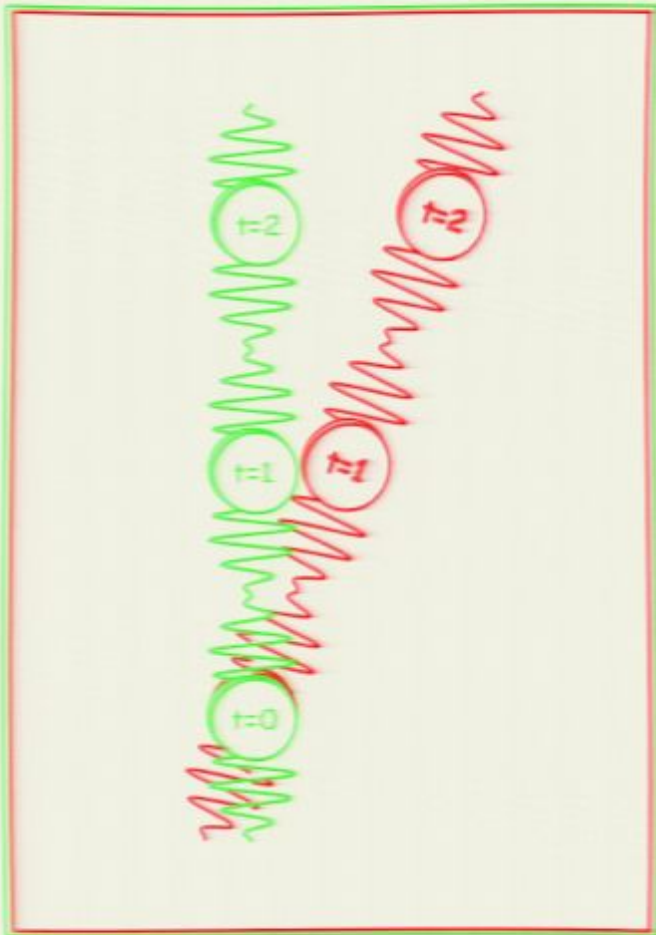
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... map out two different spaces.

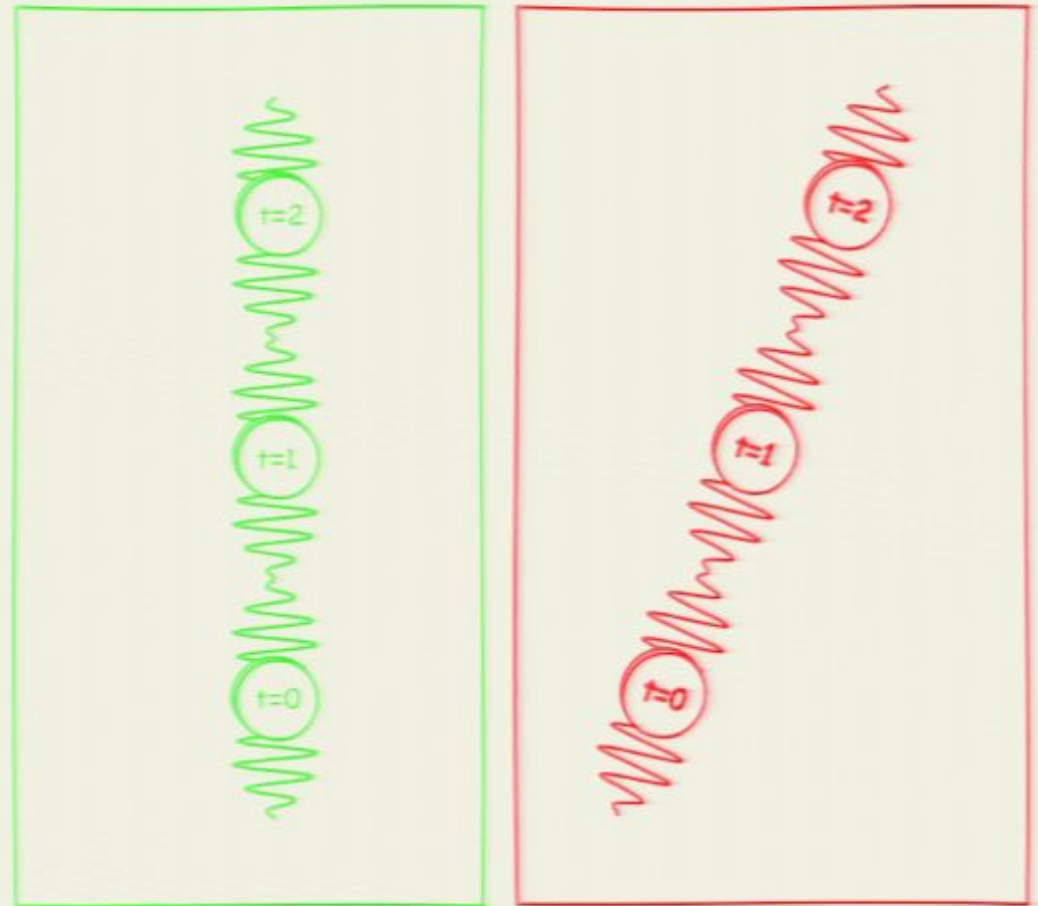


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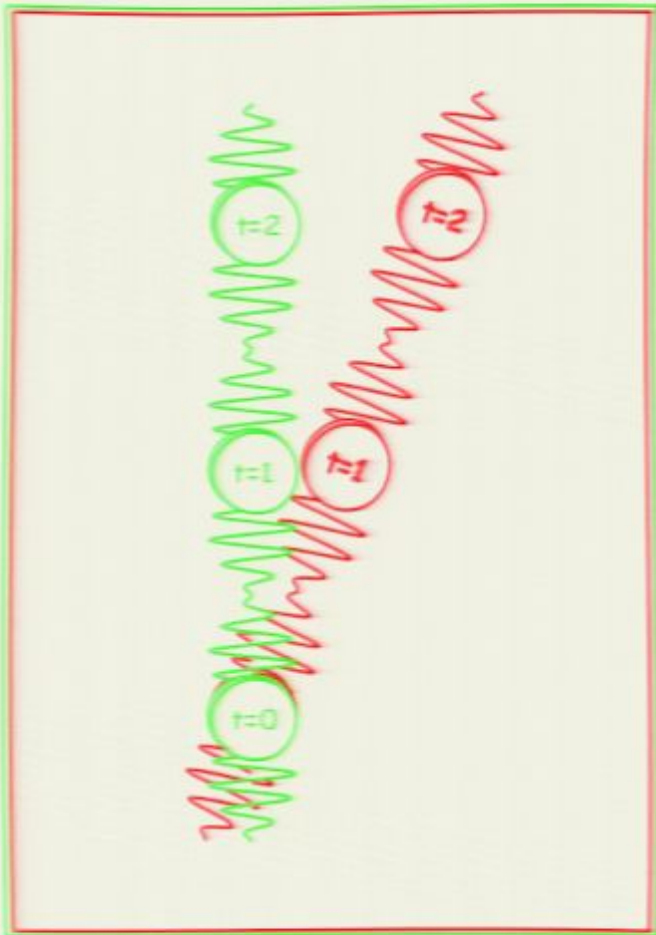


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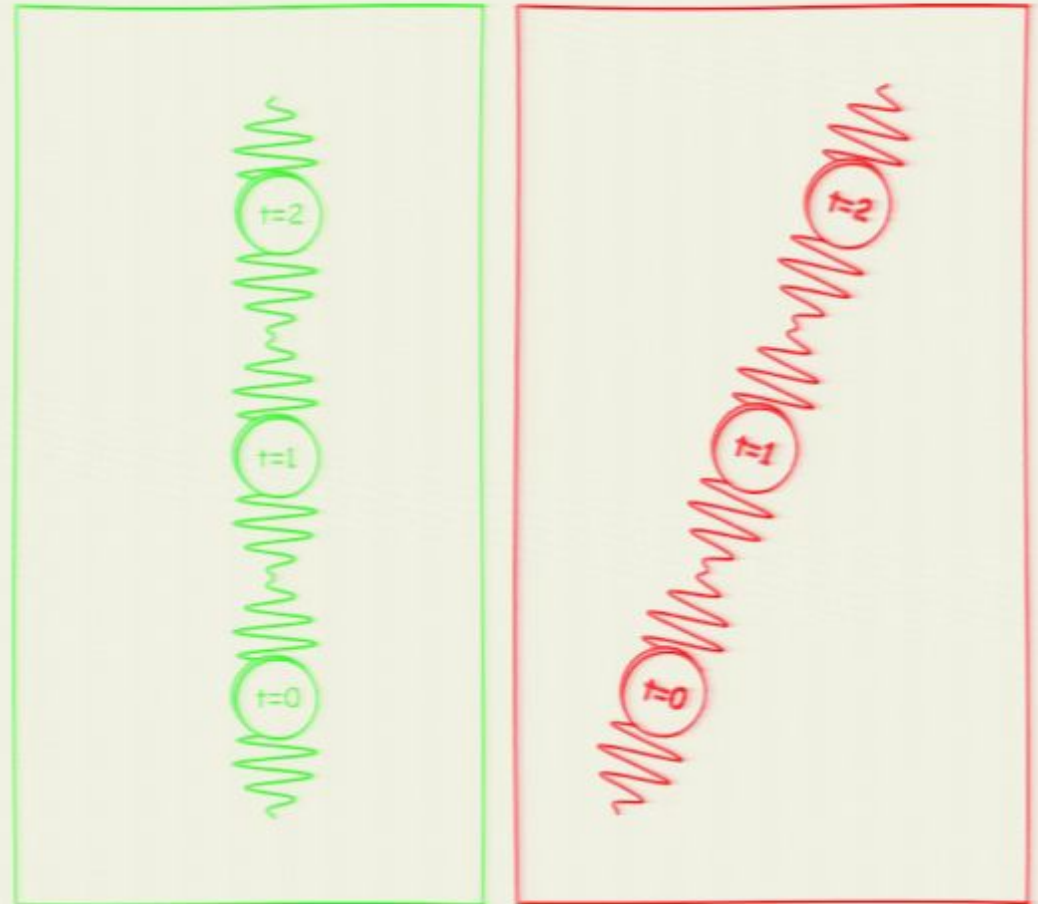


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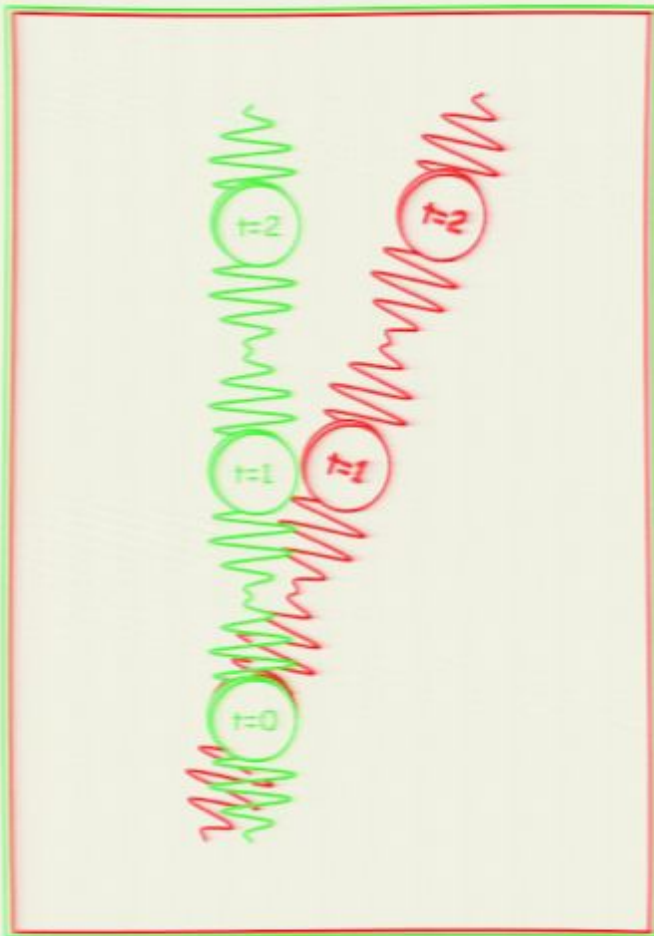


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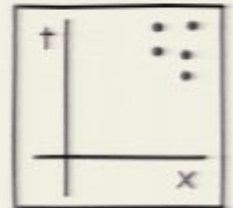
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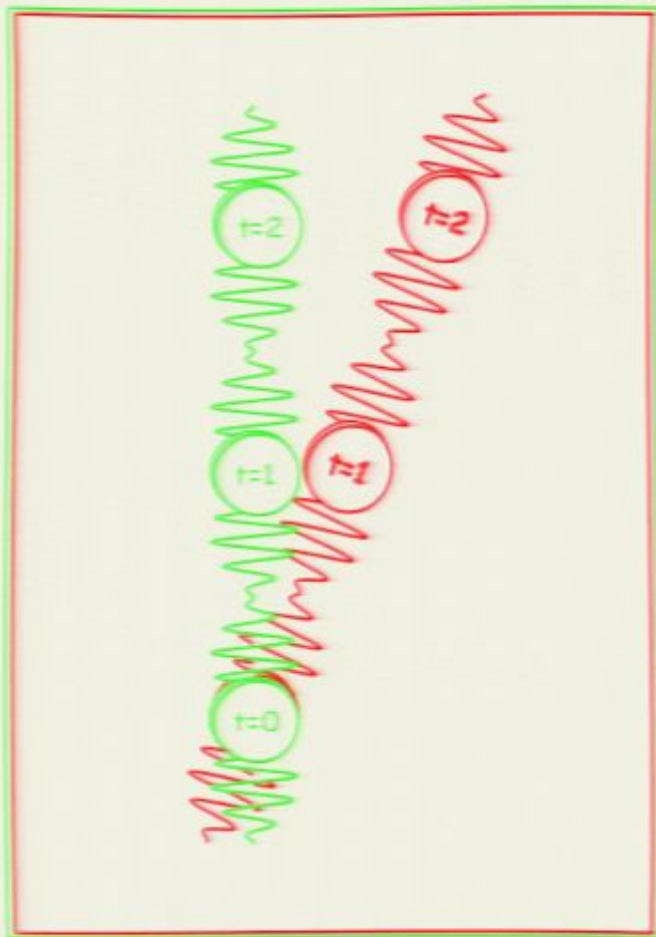
Ensure this by assuming that the x , y , z , t of each matter theory are coordinates of (a) of the spacetime realist's conception.

(a) There exists a four-dimensional spacetime that can be coordinatized by a set of standard coordinates (x, y, z, t) , related by the Lorentz transformation.

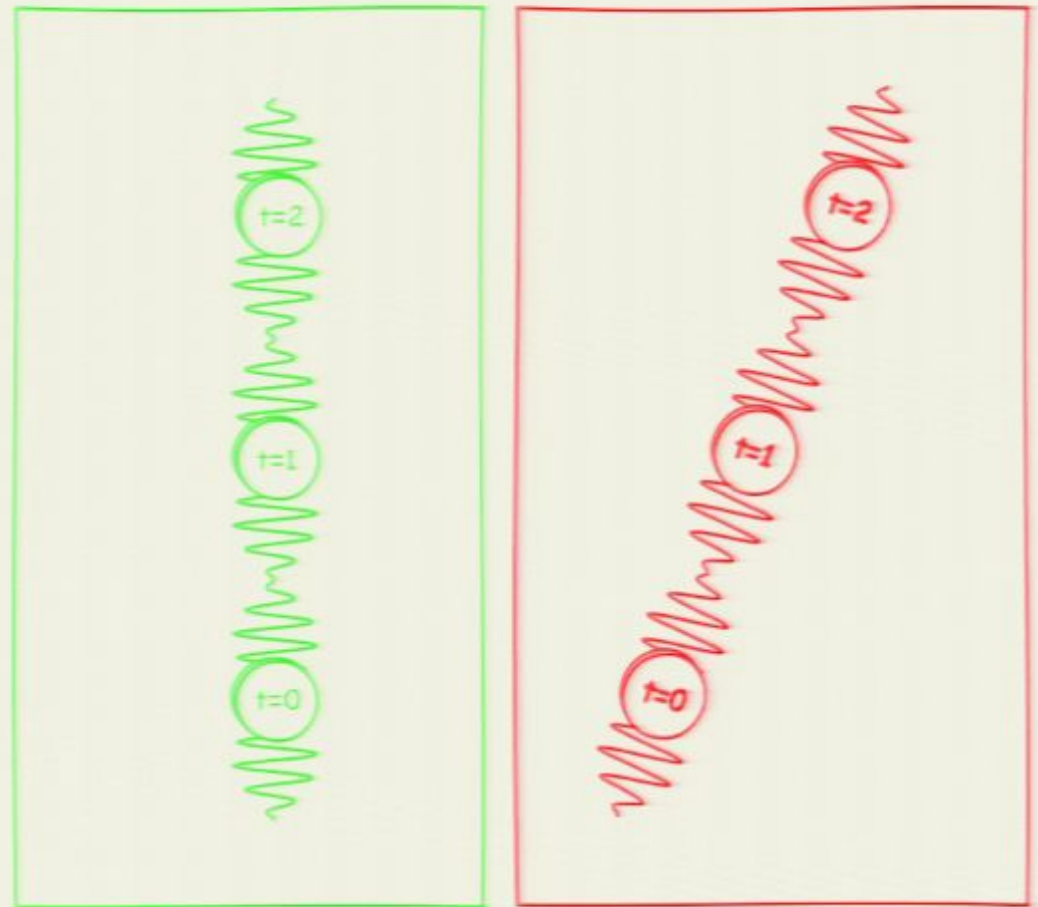


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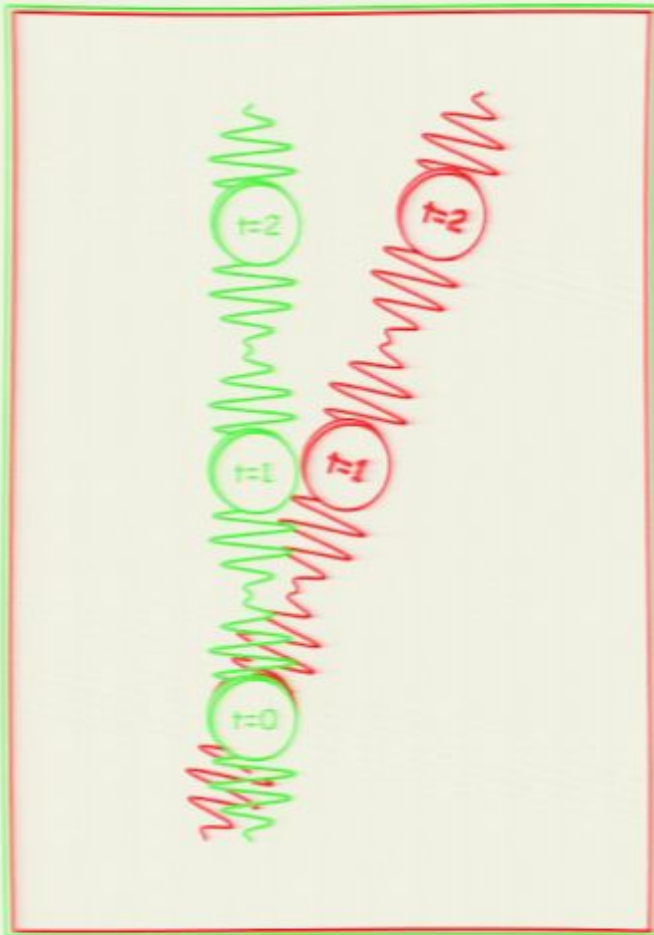


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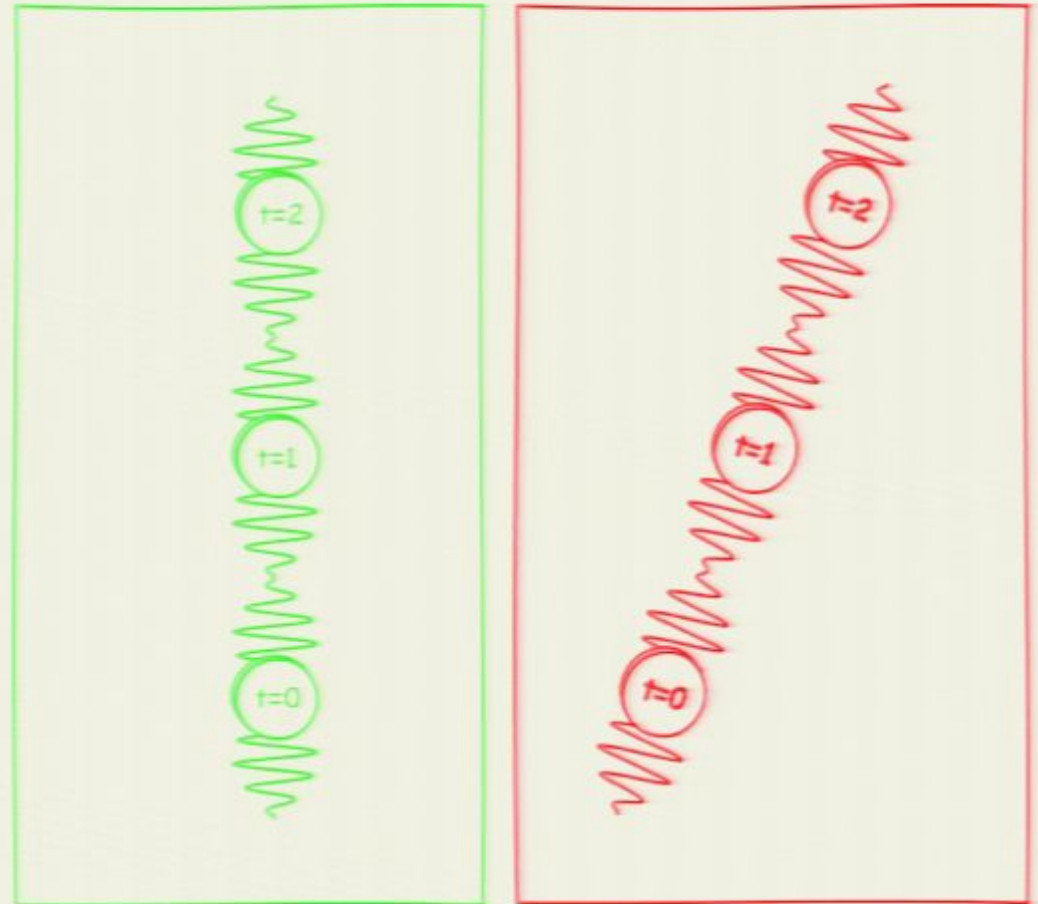


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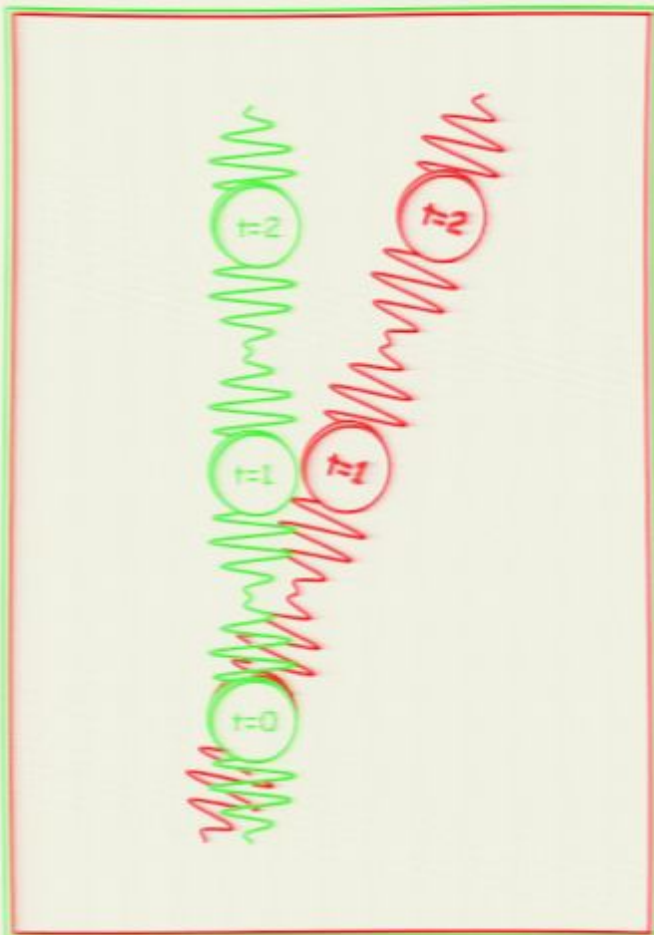


... map out two different spaces.



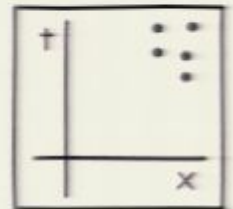
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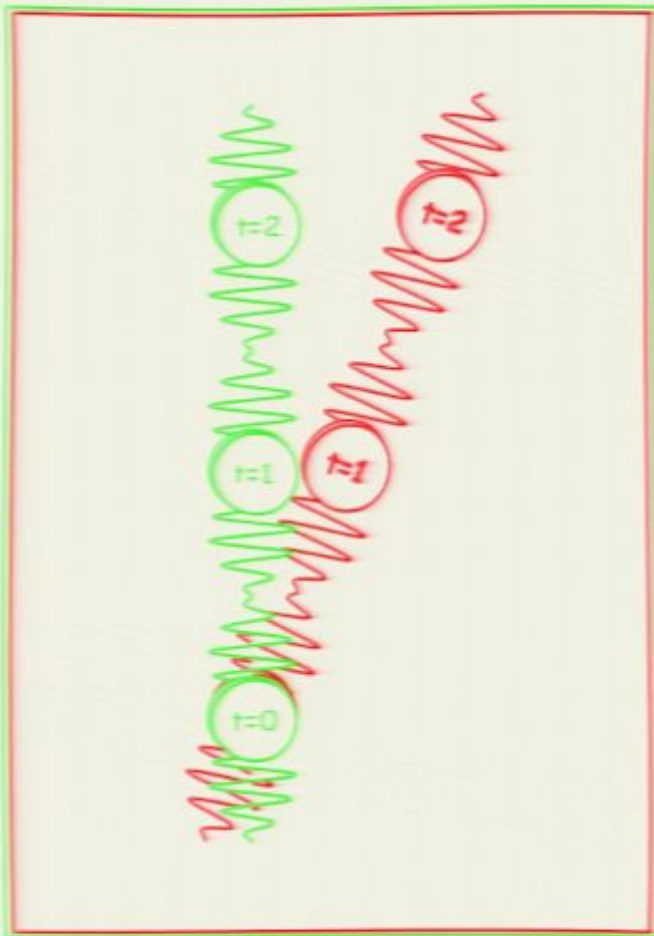
Ensure this by assuming that the x , y , z , t of each matter theory are coordinates of (a) of the spacetime realist's conception.

(a) There exists a four-dimensional spacetime that can be coordinatized by a set of standard coordinates (x, y, z, t) , related by the Lorentz transformation.



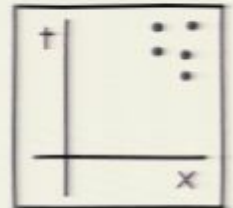
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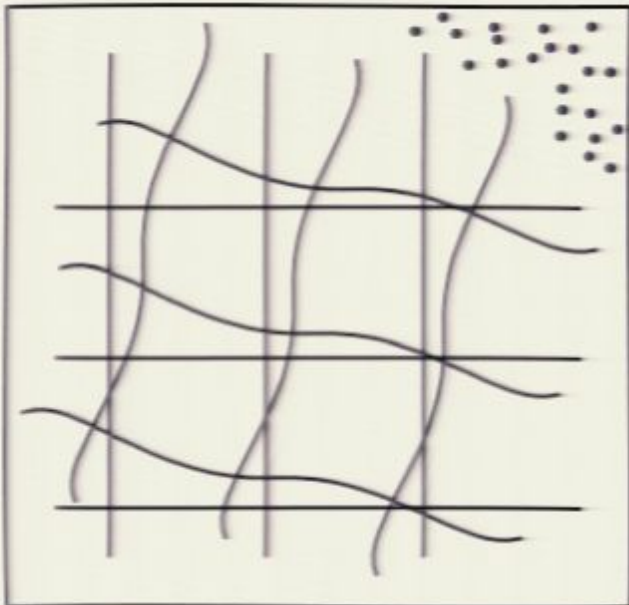
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Escape through a weakened version of dynamical-constructive view?

Assume with realist that there is one spacetime manifold of events with all possible coordinate systems.

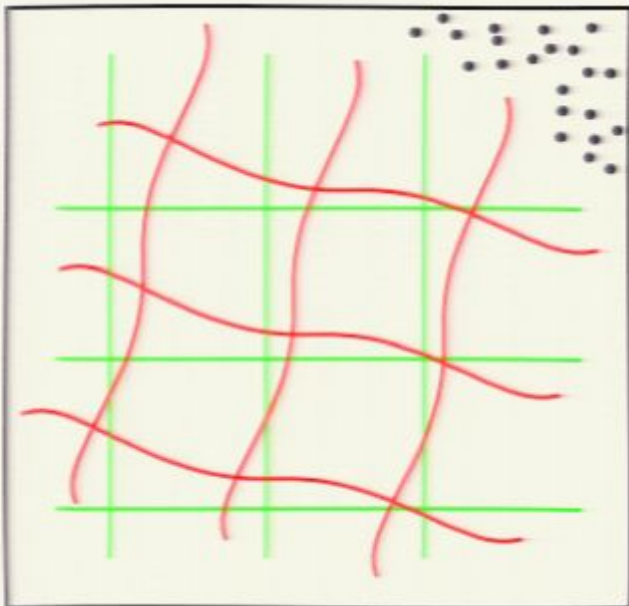
Use constructions with material clocks and rods to pick out the standard coordinate systems of (a).



Escape through a weakened version of
dynamical-constructive view?

Fails

How do we know that **matter theory 1** and **matter theory 2** picks out the same standard coordinate system?

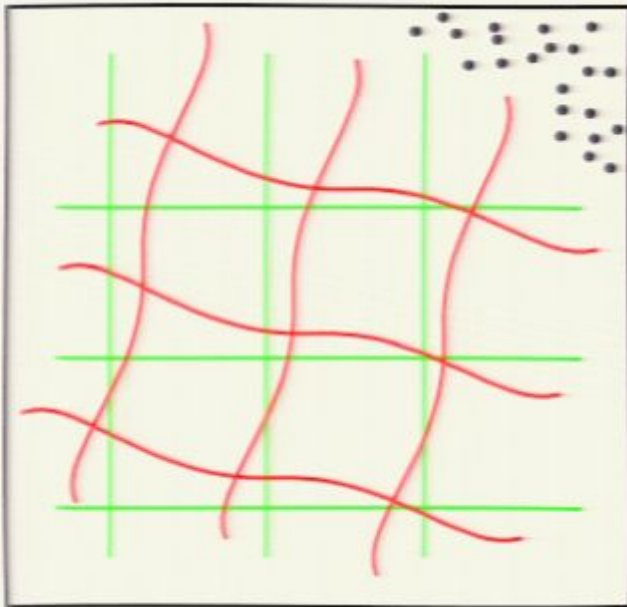


Escape through a weakened version of dynamical-constructive view?

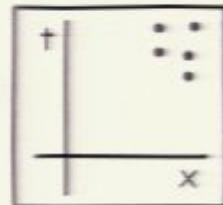
Fails

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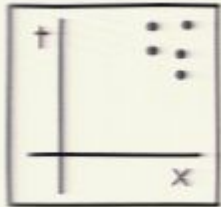
We must assume the rest of (a)--that there is just one set of standard coordinate systems to be found.



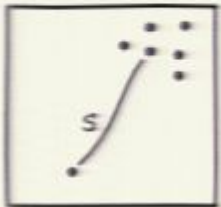
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Realist's Conception



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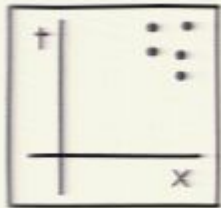
(b) The spatiotemporal interval s between events (x, y, z, t) and (X, Y, Z, T) along a straight line connecting them is a property of the spacetime, independent of the matter it contains, and is given by

$$s^2 = (t-T)^2 - (x-X)^2 - (y-Y)^2 - (z-Z)^2$$



(c) Material clocks and rods measure these times and distances because the laws of the matter theories that govern them are adapted to the independent geometry of this spacetime.

Realist's Conception



(a) There exists a four-dimensional spacetime that can be coordinatized by a set of standard coordinates (x, y, z, t) , related by the Lorentz transformation.

Independent spacetime must be presumed to avoid the problem of coincidences.



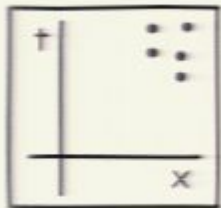
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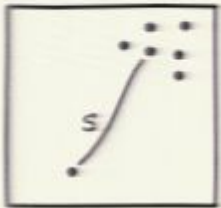
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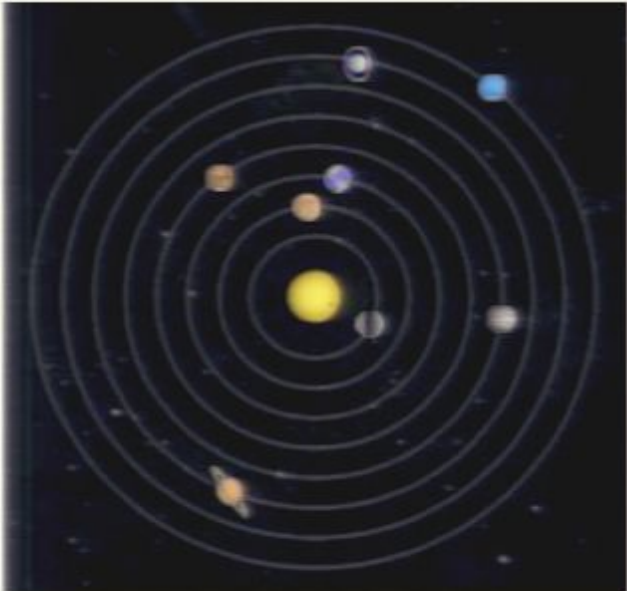


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Hence infer adaptation of independently existing spacetime and matter.

Primacy of spacetime structure

Common Origin Inferences

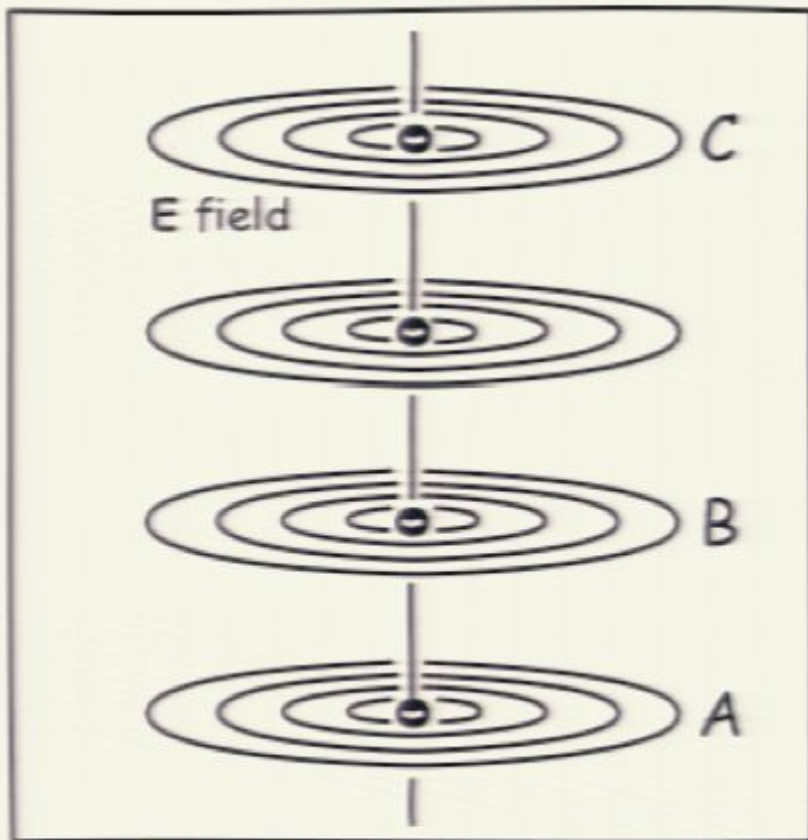


Planets, comets all orbit the sun.

Infer to common origin:
They are responding to same
thing, the gravitational field of
the sun.

A narrow form of
inductive inference
that I distinguish
from “inference to
the best explanation.”

Problem of unchanging systems.



Standard electrodynamics admits the possibility of a universe with one electron in it whose instantaneous state does not change at all over time.

The broader debate

General Relativity Spacetime geometry and the matter of the gravitational field are now both represented by one structure, the metric field.

So, someone has won the debate. But who?

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Dynamical-constructivists? A matter theory has annexed spacetime geometry.

Or are we asking the wrong question?



Read

John D. Norton



hi res pic 1
hi res pic 2
hi res pic 3
hi res pic 4

Latest

Bio

CV

Includes direct links to my papers.

Research

A synopsis of my research in history and philosophy of physics and general philosophy of science, with links to papers.

Goodies

Some things are just too much fun.

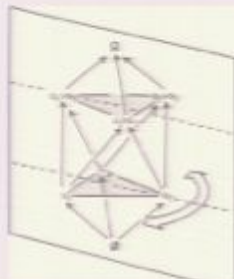
Teaching

Complete syllabi for my courses and the complete text of "Einstein for Everyone."

Editing and Publishing

Director, Center for Philosophy of Science and
Professor, Department of History and
Philosophy of Science
University of Pittsburgh
Pittsburgh PA USA 15260
jdnorton@pitt.edu
412 624 1051

Latest



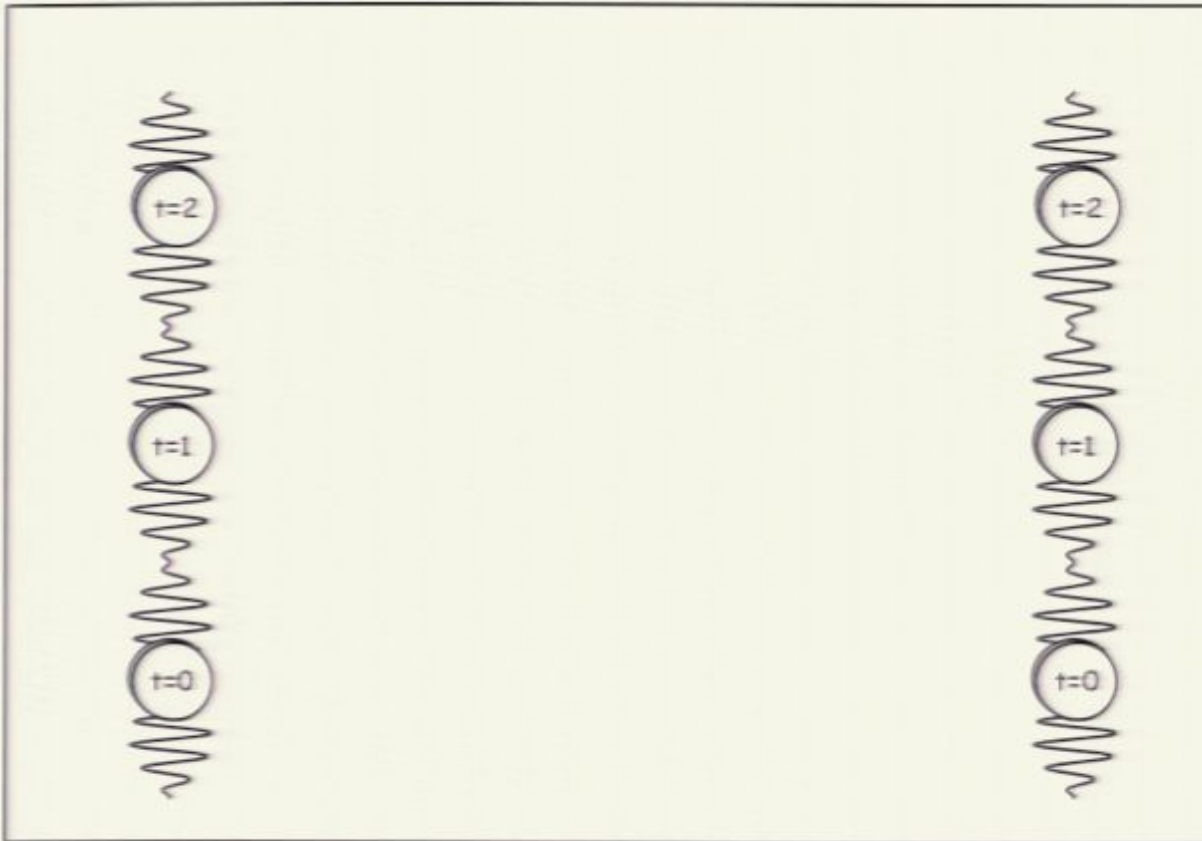
What if, like me, you don't think that the probability calculus is the One, True Logic of Induction? Then you want to know what other logics are possible. Here I map out a large class of inductive logics that originate in the idea that the inductive support B affords A , that is "[A|B]," is defined in terms of the deductive relations among propositions. I demonstrate some very general properties for these logics. In large algebras of

"Deductively Definable: Logics of Induction"
Download.



Finis

Problem of emptiness in spacetime



Two identically constituted clocks in an otherwise completely empty spacetime run at the same rate.

In dynamical-constructive view:

No material processes connect the clocks.



No basis to affirm that they run at the same rate.

Failure of complete recovery of spacetime structure of standard textbook systems.

What explains what?



Michel Janssen, “Common Origin Inference” Why do all matter theories reveal the same spacetime structure?

Structure of Minkowski spacetime

explains

Properties of matter.
Lorentz covariance of all matter theories.

explains

Lorentz covariance of all matter theories is a “brute fact.”

