Phil. 4360
Notes #18: Is Time Unreal?

Basic concepts relating to time:

- *Moments* are positions in time.
- *Events* are the occupants of time ("the contents of a position in time").
- *"Past", "present", "future":* These are (1-place) properties of a moment/event. These are not permanent (an event is future at one time, then present, then past).
- *x is earlier than y:* This is a two-place relation between moments/events. It is "permanent" (if x is ever earlier than y, then it is always so; they can't change their relation).
- *The A-Series:* The series of past, present, and future moments.
- *The B-Series:* The series of moments, as ordered by earlier-later relations.
- *The C-Series:* The series of events, as ordered, but not necessarily in a temporal order.
  - The C-series is not *per se* temporal, because the existence of an 'order' does not necessarily involve *change*, and change is necessary to have time.
  - Supposedly, the C-series plus the A-series yields the B-series. (Once you know the order of events, and you know how far past/future each is, then you can infer the existence of all the earlier/later relations.)
  - Also, the C-series has no preferred order.
  - [Yes, it is really unclear what the C-series is, or what it is needed for. Why isn't the A-series sufficient?]

The Argument against Time:

I. The A-series is essential to time.

A. Time cannot exist without change.

B. Without the A-series, there can be no change.
General idea: because the only thing that ever really changes (if anything does) is that future events become present, and then past. Elaboration:

1) An event cannot change its position in the B-series. (Premise)
2) An event cannot become or cease to be an event. (Premise/From 1?)
3) An event cannot become another event. (Premise)
4) The characteristics of an event never change, other than its position in the A-series. (Premise)
5) Therefore, the only thing about an event that can change is its position in the A-series. (From 1-4)
6) Therefore, without the A-series, events cannot change. (From 5)
7) If the things that are in time do not change, then there is no change. (Premise)
8) Events are the things that are in time. (Premise)
9) Therefore, if events do not change, there is no change. (From 7, 8)
10) Therefore, without the A-series, there is no change. (From 6, 9)

II. The A-series does not exist.

- What are pastness, presentness, & futureness?

A. If they exist, they are properties/relations that apply to events.

B. They are not relations of an event to anything.
   1. They are not relations between events.
   2. They are not relations of an event to a time.
   3. Therefore, they are not relations of an event to anything. (From 1, 2)

C. They are not properties of events.
   1. If they are properties, they are incompatible properties.
   2. If events have these properties, then every event has all three of them. (Because the same event is future, then present, then past.)
   3. Thus, if they are properties of events, then events have incompatible properties (which is absurd).

D. Therefore, they do not exist. (From A, B, C)

III. Therefore, time does not exist.

Conclusion: Even though there is no time (no A-series or B-series), there is probably a C-series.

Objections:

- To I:
  - Fictional times: events in a fictional story form a B-series, but no A-series.
  - *Answer:* Events in the story do not exist, so they are not in time either.
- To II.C:
  - There is no contradiction, because events do not have these incompatible properties *at the same time*. An event is not past, present, and future, at once. Rather

    An event may be present now*, while it* used to be *future and* will be *past.*

  - *Answer:* This creates an infinite regress, because it means:

    "An event is present in the present, future in the past, and past in the future."

  This means that you are introducing a second A-series, to explain away the contradiction in the first A-series.

The first A-series:	*The second A-series:*
• Events: Ra, Gb, etc. (a's being red, b's being green, etc.)	• Events: P(Ra), F(Gb), etc. (Ra's being in the past, Gb's being in the future, etc.)
• Their A-series properties: Ra is past, Gb is present, etc. I.e., we have P(Ra), Pr(Gb), etc.	• The new A-series properties: F(Ra) is past, P(Ra) is future, etc. I.e., we now have P(F(Ra)), F(P(Ra)), etc.

  • The problem reappears, because just as Ra appeared to be past, present, and future, now F(Ra) appears to be past, present, and future. The same thing will happen to F(F(Ra)), and so on.

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Notes #19: Time Travel

Review from last time: A-series, B-series. Why A-series is required for change. Why A-series is contradictory, the infinite regress argument.

Question: Is time travel metaphysically possible? (Is there a possible world . . . ?)
- Lewis says yes.
- There are at least three problems with time travel (below).

I. The discrepancy between times

- *Problem:* The traveler leaves on his 'journey.' 'An hour later,' he arrives . . . in the past. Thus:
  (a) His arrival is after his departure (after getting in the time machine, you wind up in the past).
  (b) His arrival is before his departure (because it is *in the past*).
  This is a contradiction.
- One answer: 2-dimensional time. His arrival is after his departure in one time dimension, but before in the other time.
- *Lewis says:* The arrival is after the departure in his personal time, not in external time.
  - *External time:* Real, ordinary time, as measured by processes outside the traveler's body.
  - *Personal time:* Roughly, amount of aging & other internal processes in the traveler.
  - Thus, the traveler's arrival in 100 A.D. is before (in external time) his departure in the time machine in 2100 A.D. But he is a bit older at his arrival in 100 A.D. than at his departure in 2100 A.D., has 'memories' of the events of 2100, etc., making the arrival later in his 'personal time.'

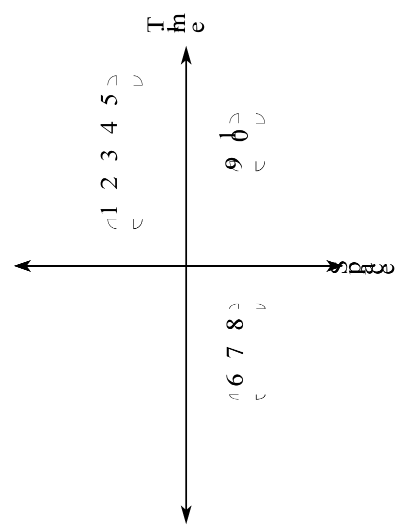

Figure 1. A time traveler. He is a disconnected spacetime worm. The numbers represent stages in his body's development (his physiological age). From his point of view, he started out at 1, then got into a time machine at 5 and went into the past. Then he got into a time machine again at 8 and went into the future, at which point he and his earlier self both existed in different places at the same time. He dies at age 10.

II. Alternate descriptions of what happened

- *Objection:* In figure 1, here is what really happened: There are three people:
  - First, a (physiologically) 6-year-old person appeared out of nowhere (call him A). Three years later, he got into a machine labeled "time machine", and the machine destroyed him.
  - Some time later, a very similar person was born. Call him B. He lived for 5 years before foolishly getting in another machine labeled "time machine," which destroyed him.
  - Two years into B's life, a third person, very similar to the first two but 9 years old, appeared out of nowhere. Call him C. C lived 2 years, and then died.
  - Question: Why isn't this a permissible description of the events depicted in figure 1?

- *Lewis says:* What distinguishes the case of time travel from the above description is:
  - A, B, and C are all (temporal parts of) the same person, not three different people.
  - Why? Two criteria of personal identity: (i) Continuity of physical and physiological properties, (ii) C causally depends on B, who causally depends on A.
  - Remember that on Lewis' analysis of causation, backwards causation is possible. Thus, nothing prevents time travel.

III. The grandfather paradox

- Tim is a time traveler, who travels back to 1921 to kill his grandfather (before he, Tim, was born).
- *Problem:*
  1. If Tim can travel back in time, then Tim can kill his grandfather before Tim's father was conceived.
     Why not? Is there some kind of "time police" that are going to stop him from doing it?
  2. Tim cannot kill his grandfather before Tim's father was conceived. For:
     a. This would be inconsistent with Tim's existing in the first place.
     b. Anyway, it is logically impossible to change the past. 1921 only happens once (in 1921). It doesn't happen one way "the first time" and then, later, happen a different way.
  3. Therefore, Tim cannot travel back in time.
- *Lewis says:*
  - The argument is an equivocation.
  - In general: X can do A = X doing A is consistent with certain facts. (Notice how you can get logical possibility, physical possibility, and epistemic possibility.)
  - Two senses of "can":
    - Tim's killing grandfather is consistent with the facts about his current state in 1921, his rifle, his training, etc. (Tim has the right equipment for killing grandfather.)
    - Tim's killing grandfather is *not* consistent with the facts in his, Tim's, personal past.
    - Thus, Tim can kill grandfather, and he can't (in two different senses).

IV. Alternate view of time travel:

- The branching view of time:
  In 1921, the universe splits into two identical universes, but in branch A, Tim shows up with a rifle and kills grandfather. In branch B, grandfather lives until 1957, having begotten father, who begat Tim. Tim gets into a time machine in 1980, disappears from branch B, and appears in branch A in 1921. No contradiction.

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Notes #20: Absolute Space

Review/continue from last time: 3 objections to time travel; Lewis' responses. The 'branching' view of time.

The traditional dispute: Two conceptions of space, time:

- *The Relational Conception of Space:* All that exists are spatial relations between bodies.
- *The Substantival Conception of Space:* Space exists independently of bodies. Bodies merely 'occupy' space.
- *The Relational Conception of Time:* There are only temporal relations between events.
- *The Substantival Conception of Time:* Time exists independently of events. Events merely 'occupy' time.
- "bodies": Physical objects.
- "substance": Something that 'exists independently'; everything else that exists depends on substances. Also: ultimate subjects of predicates; not predicated of anything. Hence the term "substantival conception of space."
- *Note:* Please do not confuse "the relational theory of space" with the theory of relativity, which will be discussed in a later class.

Related concepts:

- Location:
  - For absolutists: The part of space a body occupies. A statement of location has the form *x*O*y*, where *x* is a body and *y* is a part (a region or point) of space.
  - For relationists: A body's spatial relation to other bodies. A statement of location has the form *x*R*y*, where *x* and *y* are both bodies. R is a spatial relation, e.g. "inside", "next to", etc.
  - Similar points apply to 'location' in time.
- Duration of an event:
  - For absolutists: The measure of the region of time the event occupies.
  - For relationists: A relationship between the beginning of the event (which is itself a small event) and the end of the event. Or, alternately: the number of cycles of a clock that pass during the event (hence, a relationship between the event and some other process).
- Motion:
  - *Absolute motion:* change in the part of space a body occupies, over time.
  - *Relative motion:* change in the spatial relations between bodies.
  - Note: Substantivalists believed in absolute motion; relationists believed in only relative motion, for obvious reasons. Thus, traditional substantivalists were also *absolutists*.
  - Example: Suppose you walk at 5 mph on the deck of a ship. The ship is moving at 20 mph in the ocean. Finally, the earth is moving at 1000 mph *in space*. All these motions are in the same direction. Then your *absolute motion* is 1025 mph (the sum of these motions). Alternately: Suppose your absolute motion is 1025, and the ship's absolute motion is 1020. Then your relative motion, relative to the ship, is 5 mph (the difference in the absolute motions).
  - *Question:* Is absolute motion "motion relative to absolute space"? No; that tries to define absolute motion in terms of relative motion. Relative motion is "difference in absolute

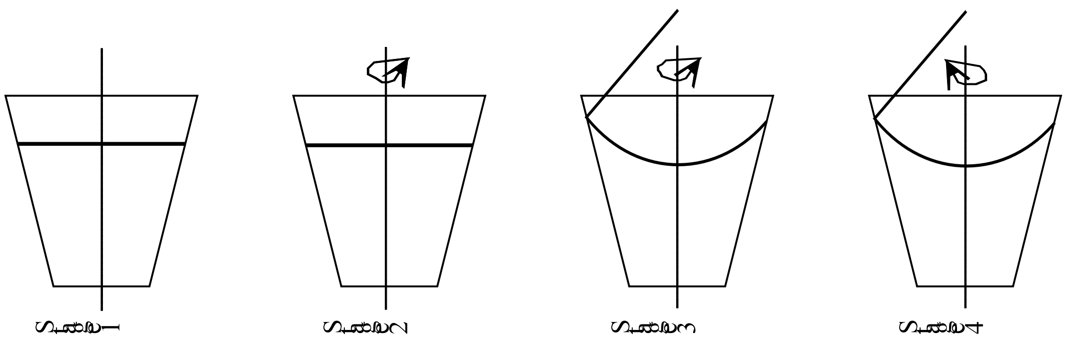
motions."

Measuring:

- We measure the *size* of a body by comparing it with another, *rigid* body (a body that doesn't change its own size).
    - For absolutists: This means it does not change the amount of space it takes up.
    - For relationists: It retains the same "bigger than"/"smaller than" relations to a lot of other bodies.
- Similarly, we measure the *duration* of an event by comparing it with a *uniform* motion/process (a process that continues at a constant speed).
    - For absolutists: It does not change the amount of absolute time that each cycle takes up.
    - For relationists: It keeps a constant relationship (keeps synchronized) with lots of other processes.

Newton's Bucket:

- A bucket of water is suspended from a rope. The bucket is turned around several times, twisting the rope up.



Stage		Relative motion of water w/ respect to bucket	Surface of water
1.	Before releasing bucket.	0	Flat
2.	Bucket is released, starts spinning as rope unwinds.	←	Flat
3.	Water picks up motion of the bucket, starts 'spinning with the bucket.'	0	Concave
4.	Rope has twisted up in the other direction, starts unwinding again. Bucket spins in the opposite direction from stage 2.	→	Concave

- *Newtonian account of the events:*
    - *Newton's First Law:* Bodies at rest tend to remain at rest, and bodies in (absolute) motion tend to remain in (absolute) motion in a straight line, unless compelled to change their state by forces impressed on them.

    - ‘Centrifugal forces’ appear for rotating bodies: The ‘force’ pushing towards the outside of the circle is really just the tendency to continue in a straight line.
    - Centrifugal force exists in stage 3, 4, because the water is rotating absolutely.
- *Relationist cannot explain this.*
    - Newton’s first law is malformed, according to them: there is no such thing as absolute motion in a straight line.
    - Suppose you substitute “relative motion”: “Bodies in relative motion tend to remain in relative motion in a straight line unless compelled to change their state by forces impressed on them.” Motion relative to *what*? Everything? This is false.
    - The relative motions in stages 1 and 3 are the same (0), but there is centrifugal force in stage 3, not in stage 1. Why?
    - The relative motions in 2 and 4 are the same (in opposite directions, but that shouldn’t matter), but there is centrifugal force in 2 but not in 4. Why?
- Thus, the centrifugal force is completely unrelated to the *relative* motions. It can only be explained by the absolute motion of the water.

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Notes #21: Leibniz vs. Clarke

Leibniz' views:

- Relational theory of space, time.
- Deduces this from the *Principle of Sufficient Reason:* For every fact, there is a reason why it is so, rather than otherwise.
- A vacuum is impossible, because then there would be 'space' existing apart from matter.

Leibniz, Against Absolute Space:

1. If space is absolute, then the following are two different situations:
   a. The world as it actually is.
   b. The world as it is except everything moved over 1 foot to the right. (There are many other variants on this.)
2. There could be no reason for (a) rather than (b).
3. Hence, if space is absolute, then there is a fact for which there is no reason.
4. For every fact, there is a reason. (The PSR.)
5. Hence, space is not absolute.

Clarke:

6. If the relational theory of space & time is true, then
   a. If God moved the universe to the right at 1 million miles per hour, the universe would remain in the same place.
   b. If he suddenly stopped this motion, there would be no shock (no effects at all).
   c. If God had created the universe 1 million years earlier, it would not have been created sooner.
7. (a), (b), and (c) are absurd.
8. The relational theory of space is false.

Leibniz:

Reply to (6):

- It is logically impossible for God to move the universe, or stop it, or to have created it sooner. (See above argument.)
- Further argument:
  9. Such a change could not be observed.
  10. Anything that can't be observed can't exist.
  11. So, such a change is impossible.

Leibniz on Newton's bucket:

- Admits that there is such a thing as "true motion," denies that it should be explained by ref. to absolute space:

  > "For when the immediate cause of the change is in the body, that body is truly in motion; and then the situation of other bodies, with respect to it, will be changed consequently, though the cause of that change be not in them." (74)

Is this a good reply?

- What is "the change"? Change in relative motions.
- What causes the water's spinning? (The bucket.)
- L's reply is very obscure. How can he admit the concept of "true motion"??

The modern reply:

- Velocity is relative.
- Acceleration is absolute.
- Rotation is a form of acceleration.
- The water is 'really' rotating in stages 3 and 4.
- *Note*: Is this compatible with the relational theory of space?

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Notes #22: Spacetime & Relativity

Review: Leibniz' 2 arguments against absolute space/time. The Pr. of Suff. Reason.

Spacetime:

- Two concepts of a space:
  - *Physical space:* the space you are moving around in.
  - *Mathematical space:* a set of things ('points') that have certain mathematical properties. Basically, they have relations to each other that enable them to be arranged along one or more dimensions. *Ex.:* logical space, the color space, the IQ-height space, various spaces in statistics. Physical space is also a mathematical space.
- Another (mathematical) space:
  Spacetime: the 4-dimensional 'space' in which the points are ordered quadruples giving (physical) spatial and temporal coordinates. Spacetime is a mathematical space; it includes physical space.
- Learn to enjoy spacetime diagrams.

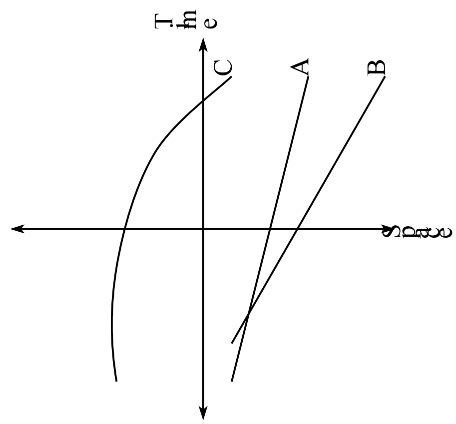

Figure 3. Spacetime. We suppress two spatial dimensions to make it possible to draw on a flat piece of paper. Vertical axis is time; horizontal axis is space. Line A represents an object moving to the right. B is an object moving *faster* to the right. C is an object *accelerating*.

What is the Special Theory of Relativity (STR)?

- It is a theory of the structure of spacetime.

Newtonian spacetime. Various features:

- Shortest path between 2 points is a straight line. Distance between points:
  $D^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 + \Delta t^2$
- Distinguishes:
  Straight lines / curved lines
  Vertical lines / slanted lines
- Spatial & temporal coordinates are separable. Spatial and temporal distances are both objective.
- No speed limit.
- See figure 3.

Minkowski spacetime. Various features:

- Shortest path *not* a straight line (but the path of a light ray). The invariant spacetime interval:
  $I^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - (c\Delta t)^2$
  Note the minus sign!
- Distinguishes:

Straight lines / curved lines

- Space & time are inseparable. Spacetime intervals are objective, but how they divide into spatial and temporal components is not.
  - There are multiple equally acceptable specifications of the time axis.
  - Hence, no absolute simultaneity.
- Has a 'light cone structure' (any given point has a forward & backward light cone); this is objective. Which s-t points are in the light cone is invariant.
- See figure 4.

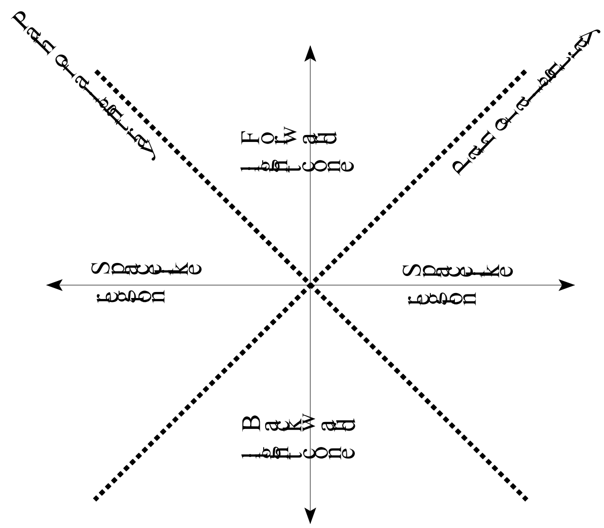

Figure 4. Minkowski spacetime. For any given spacetime point, there is a set of points that would be connected to it by a light pulse sent out in all directions: this set of points is the *forward light cone*. Similarly, there's a backward light cone. Outside the light cones are the points at 'spacelike separation.'

Famous features of STR:

- All inertial reference frames are equally good.
- The speed of light (*c*) is constant; i.e., every r.f. must agree on whether a thing is traveling at *c*.
- All of the following are 'relative':
  - Velocity of an object (if below *c*)
  - Length of an object
  - Time-order of two (spacelike) events
  - Shape of an object
  - Mass of an object
  - Duration of an event
- Nothing can travel faster than *c*. Why:
  - The putative 'stages' of the spacteime worm of such an object would be *spacelike* related to each other.
  - There is no objective time order to spacelike separated events.
  - Also, it would require infinite energy.

About relative vs. absolute quantities:

- 'Relative' quantities are those which differ between reference frames. They are not in objective reality; they are convention-dependent.
- 'Absolute' quantities are *invariant* ones: i.e., all rf's agree on them. They are in objective reality.

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Notes #23: More relativity

Review from last time: Invariants in STR: spacetime distance, speed of light, light cones. Acceleration/inertial motion. Relative quantities: velocity, length, shape, mass, time-order, duration. Why: nothing can travel faster than *c*.

About the history of relativity theory:

There are three general arguments for the theory of relativity:

1. The argument from authority:
   a. Physicists have said that STR is true.
   b. Therefore, STR is true.
   • This is the chief argument relied on by most people, including physicists.
2. The philosophical argument:
   • STR rests on the following *philosophical* theses:
     - *The verification criterion of meaning:* A statement is meaningless unless it can be verified (through experience).
     - (Related to the first.) All concepts are dependent on observations; all concepts refer to experiences one would have in certain conditions.

   • These theses amount to "logical positivism," a philosophy popular in the early-mid 20th century.
   • Notice how they appear in Einstein.
   • Notice how they are assumed dogmatically: "I would ask the reader not to proceed farther until he is fully convinced on this point." (Einstein, 22)
3. STR accounts for the null result of the Michelson-Morley experiment.

Why STR is important for metaphysics:

• Very widely accepted.
• Radically revises concepts of space & time. No separation between 'space' and 'time.' No unique time-series. Practically every thought you have about space or time is incoherent, if relativity is true.
• Also radically revises concepts of physical objects. Most of their 'intrinsic' properties are convention- or observer-dependent.
• Has been used to argue for philosophical theses:
  • In epistemology: we should listen to any absurd idea
  • Determinism
  • Against sense data

Lovejoy: Criticism of Einstein

A. Recap of Einstein's argument

Stage 1:

The radically experimental theory of meaning:

(i) A predicate has 'meaning' only if its definition identifies some directly observable event that would occur under definite conditions, and that would verify the applicability of the term.

(ii) The meaning of a term *is* the occurrence of that event (or rather: to predicate a term is to assert the occurrence of such observable event).

Stage 2:

The definition of “simultaneous.” Three kinds of event-pairs:

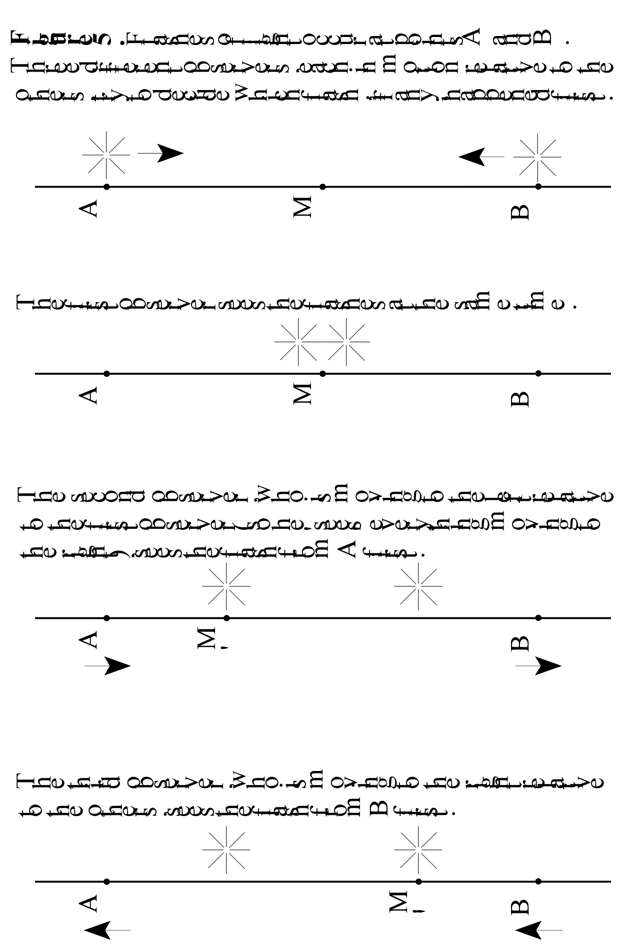
(i) Sense-data or mental events. These can be directly observed to be simultaneous or not.

(ii) Physical events occurring in the vicinity of the observer. These can also be observed to be (approximately) simultaneous.

(iii) Distant physical events. These cannot be directly observed to be simultaneous. Hence, a definition of simultaneity for them is needed:

E_A is simultaneous with E_B iff: If an observer were put at the midpoint of AB, and a light signal were sent from A at the time of E_A and another signal from B at the time of E_B, then the observer would see the light signals at the same time.

(where A is the location of event E_A and B is the location of event E_B.)



Stage 3:

The relativity of the time-order of events:

• The above def. of simultaneity leads to the following apparent contradiction (see Fig. 5):

  • The light flashes at A and B are simultaneous.
  • The one at A happened first.
  • And the one at B happened first.

• Solution: time order is ‘relative’ to a frame of reference.

B. Problems:

1. We already have a concept of simultaneity in Stage 2, (i) and (ii). Why do we need *another* definition for distant events?
   a. The def. in (iii) contains the expression “at the same time,” presupposing that we know what this means. This appears to be circular.
   b. E. must think that there are two *different* relations called ‘simultaneity’, for nearby vs.

distant events. Distant events cannot be 'simultaneous' in the same sense as nearby events.

c. What is the argument for this? The Radically Experimental Theory of Meaning → In circumstances in which the way of verifying that "F" applies to an object are different, the meaning of "F" is different.
   - This implies that, e.g., "rain" has a different meaning when someone says "it will rain tomorrow" based on a weather forecast, and when someone says "it is raining" based on seeing the rain falling.

d. Thus, there is no reason for introducing Einstein's definition, or for thinking that distant events can't be 'simultaneous' in the same sense as nearby events.
   - It may be that the means of *knowing* whether distant events are simultaneous is different.
   - It might also be that we lack such a means of knowing. Both of these would be irrelevant.

> "The experimental theory of meaning is, in fact, radically opposed to the spirit of scientific empiricism, in so far as it declares that a quality or relation which, in certain instances, *is actually* exemplified in experience *can not* exist in instances beyond the reach of experience." (629, emphasis Lovejoy's)

e. Other consequences of radical experimentalism:
   - Concept of light traveling is meaningless. There are only 'illuminated bodies'.
   - Notion of stuff happening on Arcturus 'now' is meaningless.
   - 'Distance' has a different meaning when applied to stars versus objects on the earth.
   - Statements about the past are either meaningless or just statements about the present 'traces' of past events. [Dummett actually adopted the latter view, decades after this article.]

2. Is Einstein's def. an *arbitrary* verbal definition, or is it supposed to correspond to the pre-existing meaning of the term?
   - E. accepts only (at most) three constraints on the def.: (a) that it should define a relation between events, (b) that it should not be a spatial relation, (c) that it should supply a verification criterion.
   - There are many other definitions satisfying these conditions. E.g., substitute "sound" for "light" in the definition. Or, substitute "donkey" for "light signal."
   - E's def. is an arbitrary verbal definition.
   - There is thus no profound significance to his discovery about "simultaneity."

3. Another possible way of defining 'simultaneous':
   - E's def. requires only that the observer *have been* at the midpoint of AB.
   - Why not modify the def. to require that the observer *be* at the midpoint of AB *when the light signals arrive*?
   - [Problem: Suppose the two events occur in space, so there is no rigid body between them. What are points A and B? Points in absolute space? Does the first def. mean that the observer should have been halfway between A and B *at the time* E_A and E_B happened (but this presupposes the concept of simultaneity)?]

4. The second def. in (3) is required for the two observers to be talking about the same thing. Otherwise they are not performing *the same experiment* to test the simultaneity of the events.

5. Einstein overgeneralizes. His argument (even if we ignore the preceding objections) would only show that simultaneity depends on one's state of motion parallel to the line between the two events. It doesn't vary with just *any* motion (e.g., consider motion perpendicular to that line).

6. E's definition presupposes the notion of a "time of transit" (or duration). But this presupposes a concept of simultaneity b/c it implies temporal relations between stages in a body's motion.

7. E isn't consistent, for he sometimes talks about something happening on the train "while" something else is happening on the embankment. This implies that events in the two reference frames occupy the same time-series. (Maybe the point here is that E. fails to specify in which reference frame these events are simultaneous.)

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Notes #24: Non-Euclidean Geometry

I. About Pure Geometry

- Three kinds of geometry:
  ("Parallel" lines: Lines that do not cross.)
  a) *Elliptical geometry* : through a given point outside a given line, there are no parallel lines.
  b) *Hyperbolic geometry* : through a given point outside a given line, there are infinitely many parallel lines.
  c) *Euclidean geometry* : through a given point outside a given line, there is exactly one parallel line. (This is the "axiom of parallels.")
- Two kinds of geometry:
  Pure geometry is a word game with made up, stipulative definitions and rules. No connection to reality needed.
  Applied geometry is the application of a geometrical system to some thing in the world.

a) A model of elliptical geometry: The "plane" is the surface of a sphere. The "straight lines" are great circles.

- Features of this geometry:
  1) No parallel lines.
  2) The interior angles of a triangle will be more than 180°.
  3) C/d of a circle $< \pi$.
- Note: Again, "line", "triangle", etc. are *not* used in the ordinary English sense of the words.
- This surface has "positive curvature".
- This proves: Elliptical geometry is consistent.
- Why is it called "elliptical": it can be modeled on the surface of an "ellipsoid".

b) A model of hyperbolic geometry: The "plane" is a saddle surface (surface of a hyperboloid). "Straight lines" are geodesics.

- Features of this geometry:
  1) Many parallel lines.
  2) The interior angles of a triangle will be less than 180°.
  3) C/d of a circle $> \pi$.
- This surface has "negative curvature".
- This proves: Hyperbolic geometry is consistent.

- *Note* : Two senses of "curvature":
  a) Physical curvature
  b) Mathematical "curvature"

II. About general relativity:

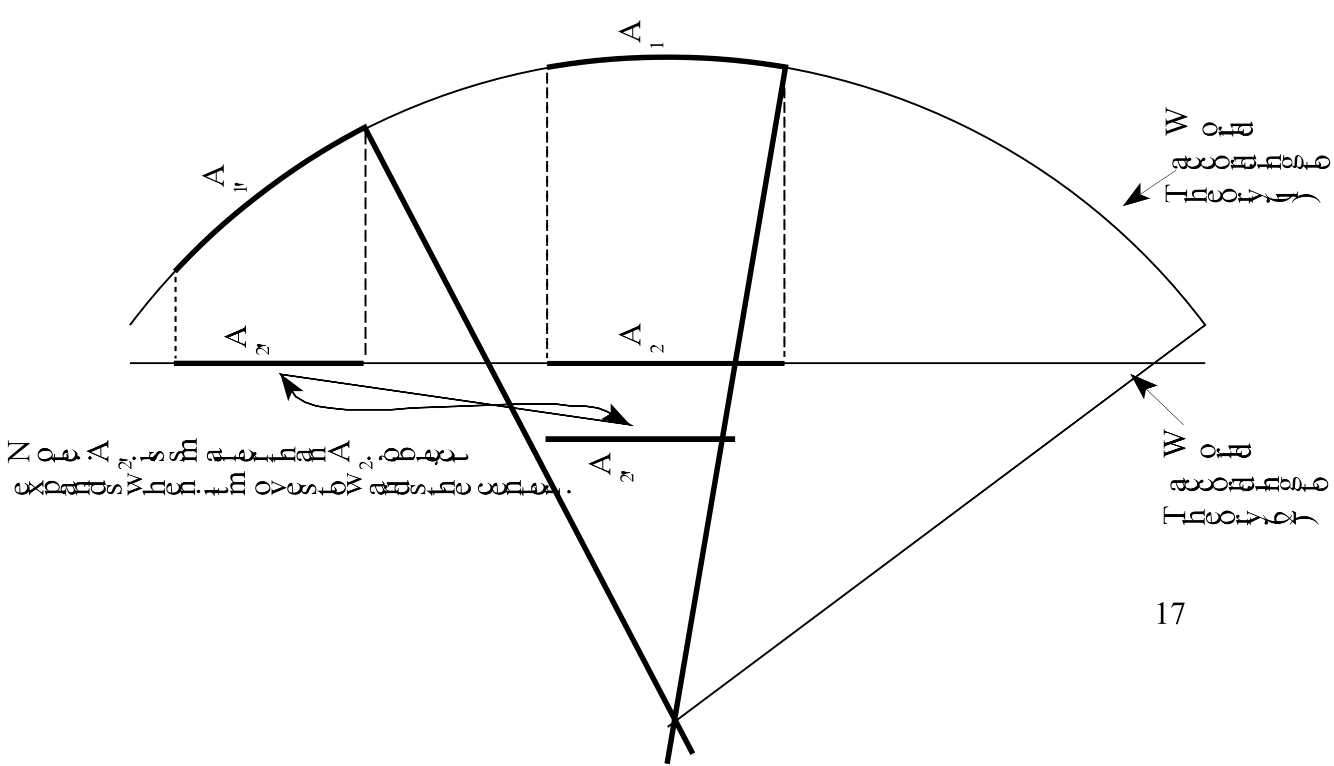
- Spacetime as a mathematical space. (Note: Lots of things are "spaces" in the mathematical sense, although they have nothing special to do with physical space.)
- Points as ordered quadruples. ("event" locations)
- Newton's spacetime: Euclidean.
- Einstein's theory:

1. Concentrations of mass/energy alter the geometry of spacetime, "curving" spacetime. Note:
   a) *Spacetime*, not *space*
   b) It is not *physically* curved. It is curved in the mathematical sense.
   • In this geometry,
   a) Points are ordered quadruples again
   b) Straight lines are paths traced by light rays
2. Objects travel straight lines through spacetime when not acted on by forces. Gravitational 'force' is replaced by spacetime curvature.
3. Light always traces straight lines through spacetime.

• Empirical evidence:
  a) the bending of light around the sun
  b) gravitational red shift
  c) advance of the perihelion of Mercury

III. Two alternative interpretations (Carnap's example):

• You have two people occupying a 2-dimensional world (see diagram below).
  Theory 1 : You have rigid (fixed size & shape) rods moving on a curved surface.
  Theory 2 : Rods affected by universal forces, on a flat surface.
  • 'Universal forces': Forces that distort everything in the same way and cannot be shielded against.
  • A heuristic for seeing the relation between the theories: Imagine the theory-1-world above the theory-2-world, and a light shining directly down from above. In (2), objects expand or contract to be the size of the 'shadow' of the objects in theory (1).
• Note that they get the same empirical predictions. (See why.)
  • You cannot directly measure distortions made by universal forces.
  • They have *effects* indiscernible (by observation) to those of the noneuclidean geometry.
• Which theory is better?
  • Einstein: (1) is better.
  • Carnap: (1) and (2) are the same theory.
  • Huemer: (2) is better.



Phil. 4360
Notes #25: The Dimensions of Space (Swinburne)

Review: Parallel postulate. Elliptical, hyperbolic, euclidean geometry. Postulates of GTR. Universal force theory. Einstein vs. Carnap vs. Huemer.

The dimensionality of a space:

Three definitions:

1. Space is *n*-dimensional = *n* is the smallest number such that every point can be specified by *n* real numbers.
   Problem: Then every space is 1-dimensional. The set of ordered *n*-tuples of real numbers can be mapped onto the set of (single) real numbers.
2. A recursive definition:
   • A point is 0-dimensional.
   • If every point in a space has arbitrarily small neighborhoods that are bounded by (*n*-1)-dimensional spaces, then it is *n*-dimensional.
3. Space is *n*-dimensional = *n* is the smallest number such that every point can be specified by *n distance* (or direction) measures.

• Def. 3 is the best.

Earlier philosophers say:

• Everyone up to and including Kant agreed : space is necessarily 3-dimensional. (Incl. Kant, Galileo, Ptolemy)
  - They argue from the fact that *three and only three lines can be mutually perpendicular at a point*.
  - Problem: The necessity of the premise is no more obvious than the necessity of the conclusion.

• Opposite argument:
  1. For any *n*, there is a formally consistent *n*-dimensional pure geometry.
  2. Therefore, it is possible that space be *n*-dimensional.

  • Problem: this is invalid. Must show that any pure geometry could be a physical geometry.

• Another argument:
  1. The 3-dimensionality of space follows from
     a) The principle of total effect: The total change in momentum produced by a gravitational force on a collection of objects completely surrounding the source, is constant (does not vary with distance).
     b) The inverse-square law: Gravitational force between 2 bodies decreases with the square of the distance between them.
  2. Furthermore, (a) combined with a different law, e.g., an inverse-cube law, entails a different dimensionality of space, e.g., 4-dimensional space.
  3. The inverse square law is contingent; a different law is possible.
  4. Hence, the 3-dimensionality of space is contingent; a different dimensionality is possible.

  • Problem: This argument requires assuming that (1a) is necessary.

- Form of the argument:
  1. (a) is necessary.
  2. (b) is contingent.
  3. Hence, (a & ~b) is possible. (From 1, 2)
  4. (a & ~b) entails that space is not 3-dimensional.
  5. Hence, it is possible that space not be 3-dimensional. (From 3, 4)
- Problem: (2) is false; or, if (2) is true, then (1) is false. E.g.: The principle of total effect is contingent; or, if you think it is necessary, then you should think the inverse-square law is necessary.

Impossibility of a 2-dimensional world:

- Imagine flat 'people' living in a plane. Is this a 2-D world? No, for:
  1. It remains *logically possible* for the material objects in the plane to be lifted out perpendicular to the plane.
  2. Therefore, the location of those objects also requires specifying their elevation from the plane (even if for all objects, that elevation is '0').
  3. Thus, 3 measurements of distance are required to specify the locations of the objects.
  4. Thus, the world is 3-dimensional.
- Other comments:

  We can only conceive of the alleged 2-D world as a subset of our world (as a plane). Thus, you cannot refer to a 2-D world: "The purported description of the 2-D world fails. The world described ... would in fact be a 3-D world." (150)

Impossibility of a 4-dimensional world:

First argument:

1. If space were 4-dimensional, then it would be impossible for a 3-D space to exist. (By analogy to above argument.)
2. Therefore, if it is possible that space be 4-dimensional, then our world is not 3-D. (From 1)
3. But our world is 3-D.
4. Hence, it is impossible that space be 4-D.

Second argument:

1. If space could be 4-D, then it would be possible to see (from outside) all of the inside of an opaque volume.
2. This is impossible.
3. Hence, space cannot be 4-D.

Third argument:

1. If space could be 4-D, then one could pass through a 3-D object without touching its surface.
2. This is impossible.
3. Hence, space cannot be 4-dimensional.

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Notes #26: Review of Unit 3

<u>Know what these things are:</u>

Substantival conception of space
Relational view
Newton's bucket & what it's supposed to show
- The Newtonian explanation
- N's 1st Law of Motion
- The modern view of this

Geometry:
- The Axiom of Parallels
- Euclidean, hyperbolic, & elliptical:
  - How they differ
  - How they can be modeled
- The postulates of General Theory of Relativity
- Difference between 'universal force' theory and GTR
  - Einstein's view on them
  - Carnap's view
  - Huemer's view

Special Relativity:
- The 'invariant interval'
- Constancy of speed of light
- Terms: spacelike, forward light cone, backward light cone
- What is relative & what is invariant in the theory

__Einstein's argument
- Verification criterion of meaning
- E's def. of 'simultaneity'
- How it leads to relativity of simultaneity

<u>Know what these people said about these things:</u>

McTaggart:
- A-series, B-series
- Basic outline of his argument
- Alleged contradiction in concepts of 'pastness', 'presentness', 'futurity'
  - The infinite regress

Lewis, time travel:
- Personal vs. external time
- Criterion of personal identity
- The grandfather paradox
- The branching view of time

Leibniz:
- Pr. of Sufficient Reason
- Main arguments against abs. space:
  - Arg from Pr of sufficient reason
  - Unobservability argument

Lovejoy's view:
- On the meaning of 'simultaneity'.
- His example of the meaning of "rain"--what this shows
- (Recognize other possible examples)
- Why he thinks E's argument is against the spirit of scientific empiricism