

Events in Space-Time: Introduction to the “Aristotelian” Framework

Aristotelian Framework (Aristotelian
Space-Time) (Aristotelian Set-up)
Common-sense, “kitchen-type” mentality,
“personalized” perspective



“Democratization”



Galilean Framework (Space-Time, Set-up)
Classical mechanics, relativity of motion,
“democratic” perspective



Conflict between mechanics and electrodynamics
(propagation of light)



Relativistic Framework (Space-Time, Set-
up)
Special relativity, relativity of space and
time

Events

Event $=_{df}$ an idealized occurrence in the physical world having extension in neither space nor time.

- * something that occurs at a particular point of space at a certain moment of time

Examples:

a firecracker explosion (an infinitesimally small and instantly-burning one)
a finger snap (also “idealized”)

Firecracker explosions, finger snaps, etc. *mark* events. What is it that they mark? They mark *space-time points*.

Event $=_{df}$ a single point in space-time

Being space-time points, events exist *objectively*, even if there is nobody (and nothing) to mark them.

- ☞ The notion of a space-time point is an *abstract* one. When you think of a point, you are usually thinking of something located in space. But a space-time point would be something located in space *and* time, or in *space-time*.

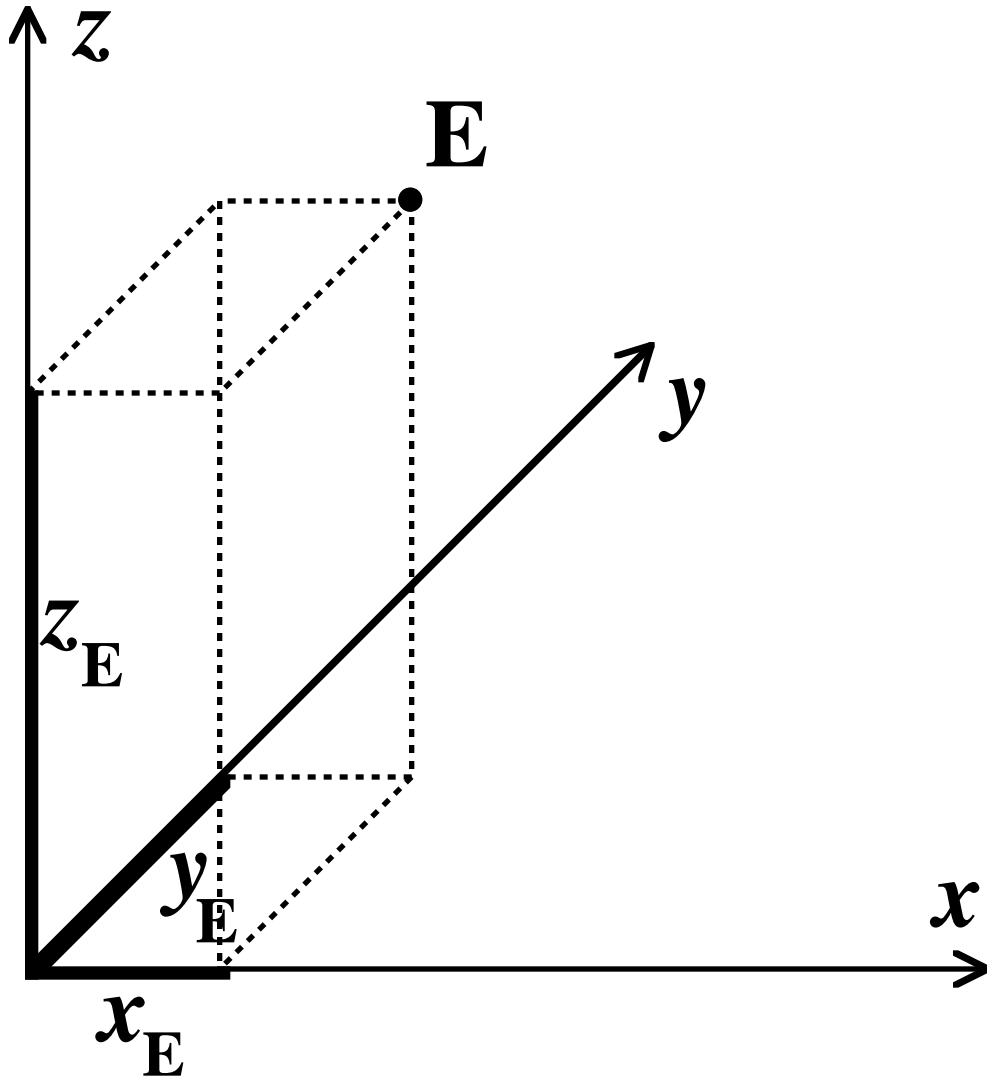
But what *IS* space-time?

- ➡ How to **describe** an event in space-time?
- ➡ According to the Aristotelian view, an event is naturally characterized by giving its position in space together with the time of its occurrence.

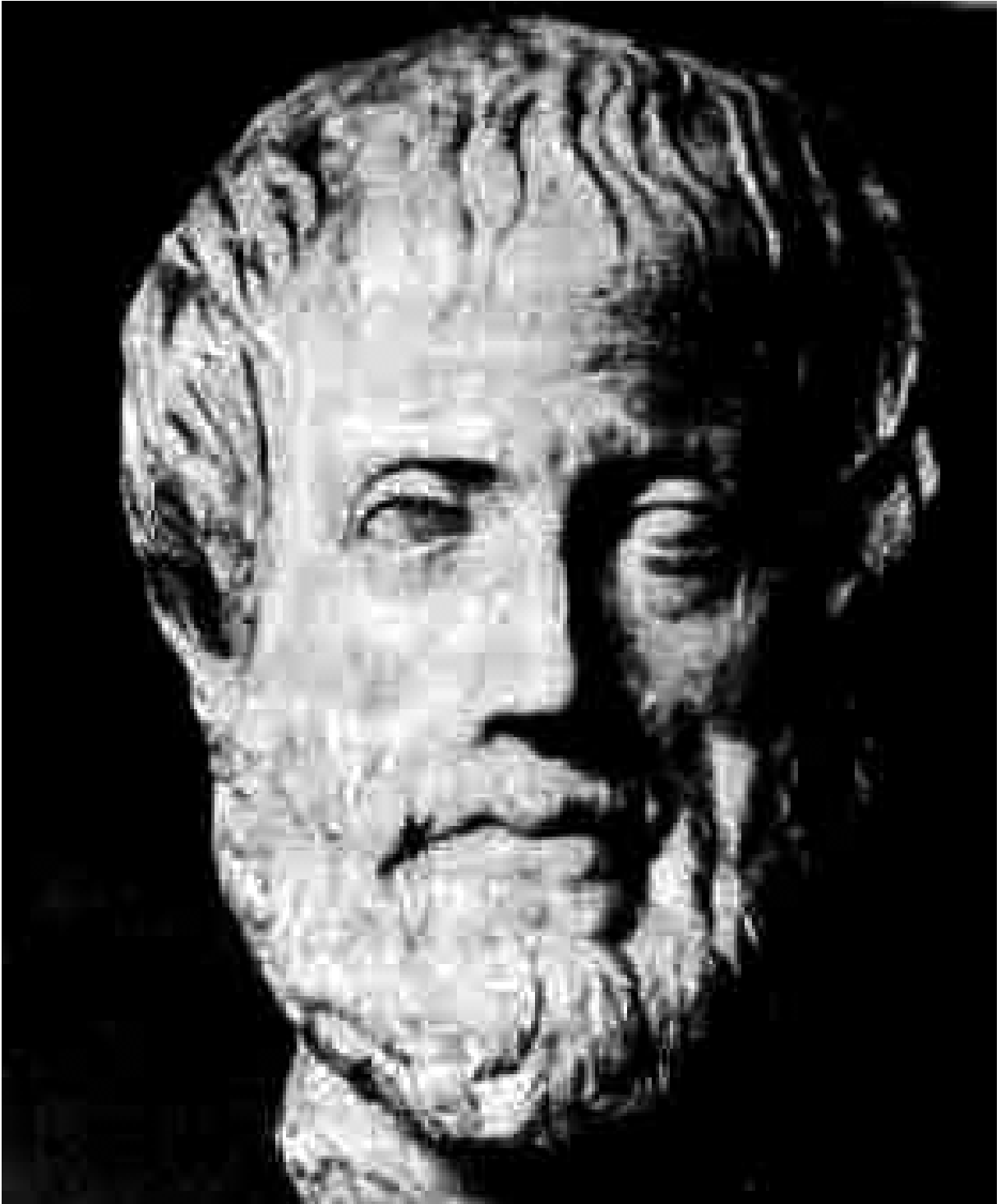
We need **four** numbers to completely identify a particular event: **three** numbers to completely characterize the location of an event in space + **one more** number to characterize the time of its occurrence.

- ➡ In a sense, an event just **is** a quadruple of numbers, and nothing more. It is a point in a certain four-dimensional **abstract space**. What is this space? It is called ***space-time***.

Aristotelian Set-up a la Geroch

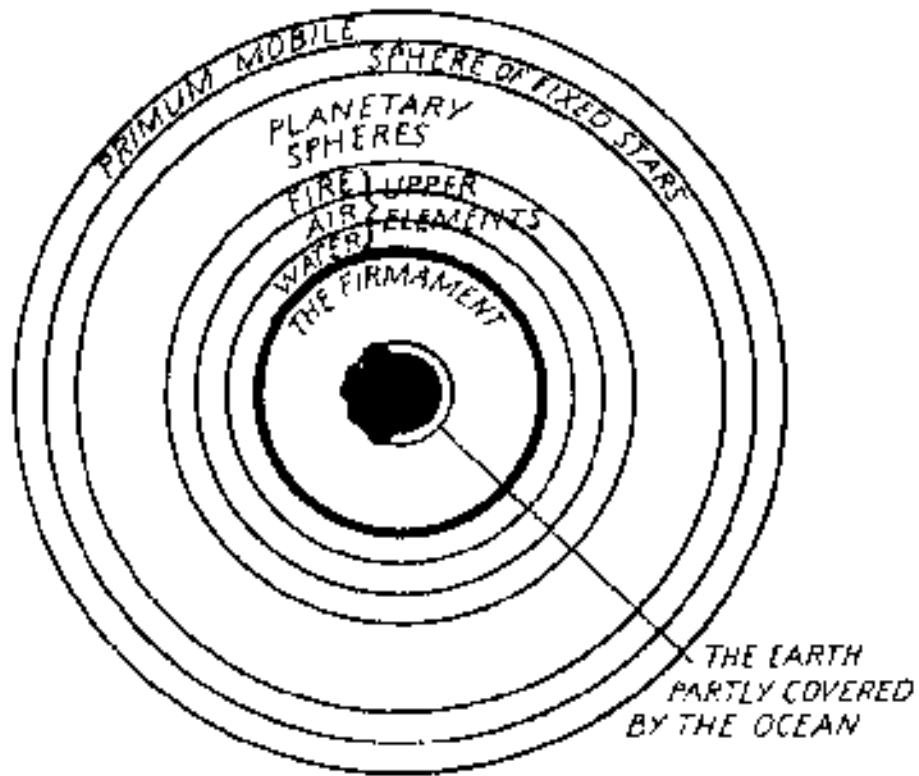


$$E (x_E, y_E, z_E, t_E)$$



Aristotle (384–322 BC)

Aristotelian Cosmology



The Universe of Aristotle as Conceived by a Medieval Writer

From Runcos' Pictorial History, p. 89.

To characterize, or describe an event to give four numbers to identify its precise location in a particular Aristotelian space-time framework. Such a framework presupposes a privileged point in space, a system of directions, a bunch of observers uniformly and densely spread out in space and equipped with watches that are all in sync. To describe an event, we give four numbers, three “written” on the badge of a nearby observer, the one whose position coincides with the spatial location of the event, and the fourth the time read off the watch of that observer.

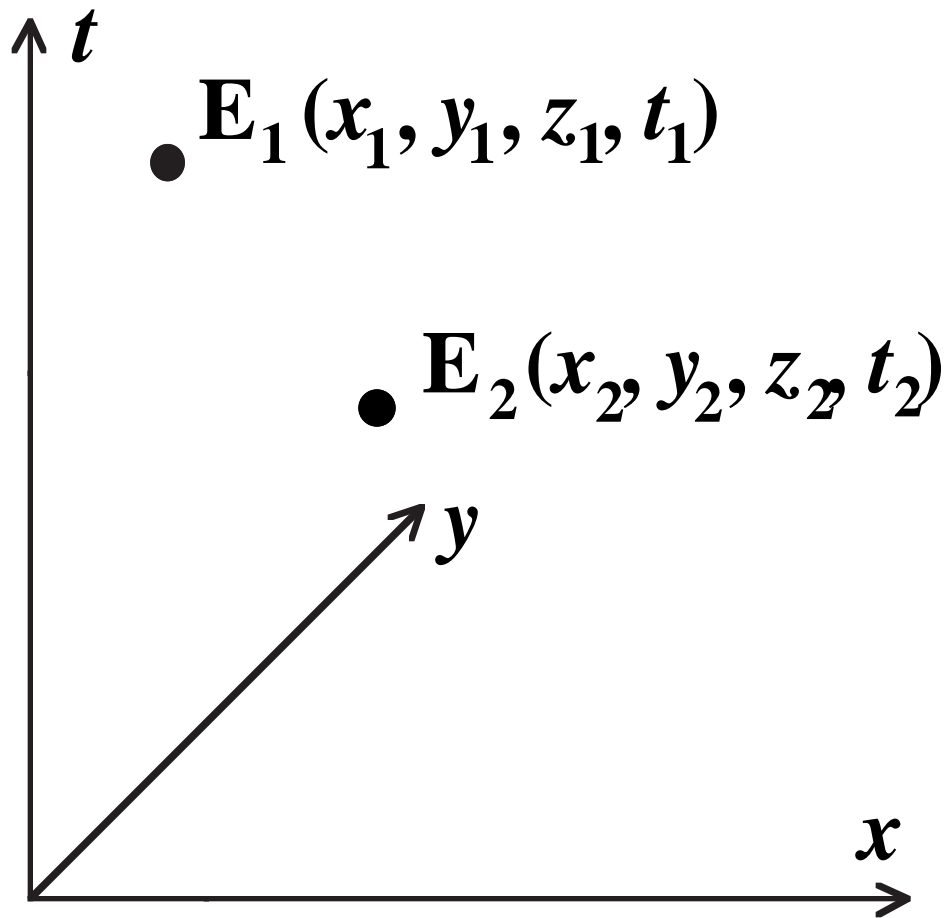
Why spend so much time on such simple things?

➡ Implicit in the Aristotelian set-up are certain assumptions about the way space and time operate. It will turn out (fairly soon) that these assumptions are **wrong** (i.e., inadequate for the physical description of the real world). To see what exactly is wrong with them, we need to make them **explicit**. The framework we set up (i.e., the observers, their badges, watches, etc.) will help us with it.

Since we can characterize events by using the Aristotelian framework, we can also characterize **relationships** between, or among, events.

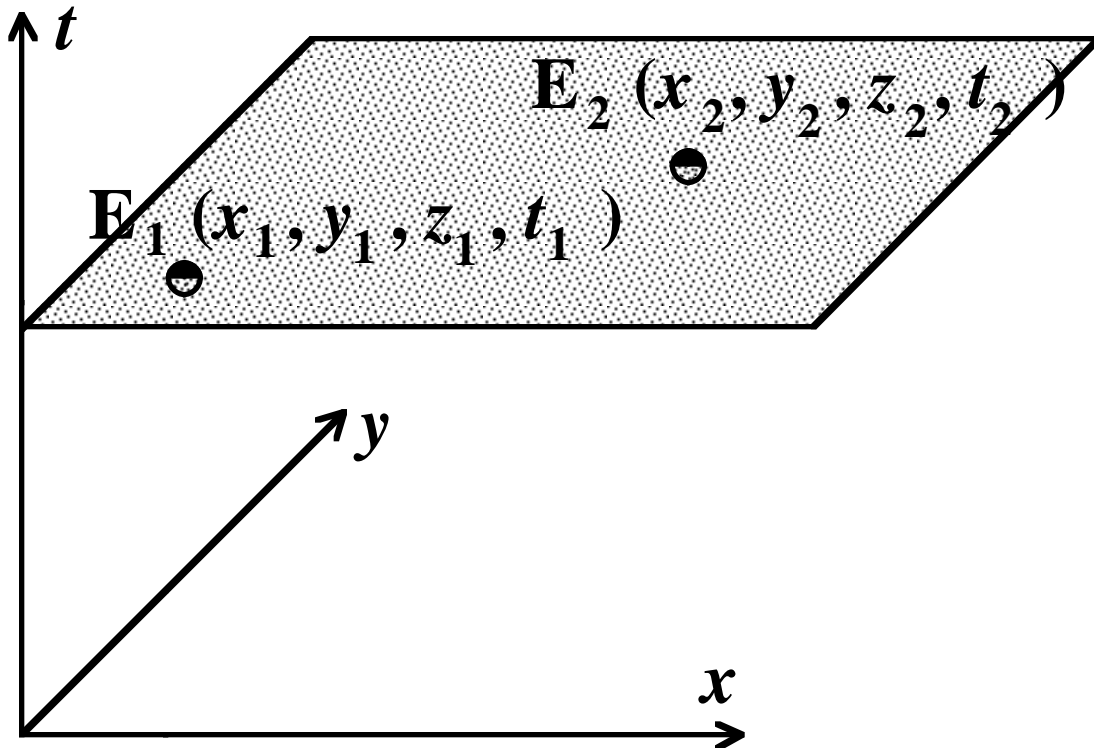
Our ultimate concern will be relationships among events. We will be looking for the **right** theory of such relationships.

- ☞ The primary significance of every particular framework we'll be studying (i.e., Aristotelian, Galilean, and relativistic) lies in what sorts of relationships among events are meaningful in it, i.e., what sorts of questions about events can be meaningfully posed and answered in that framework.



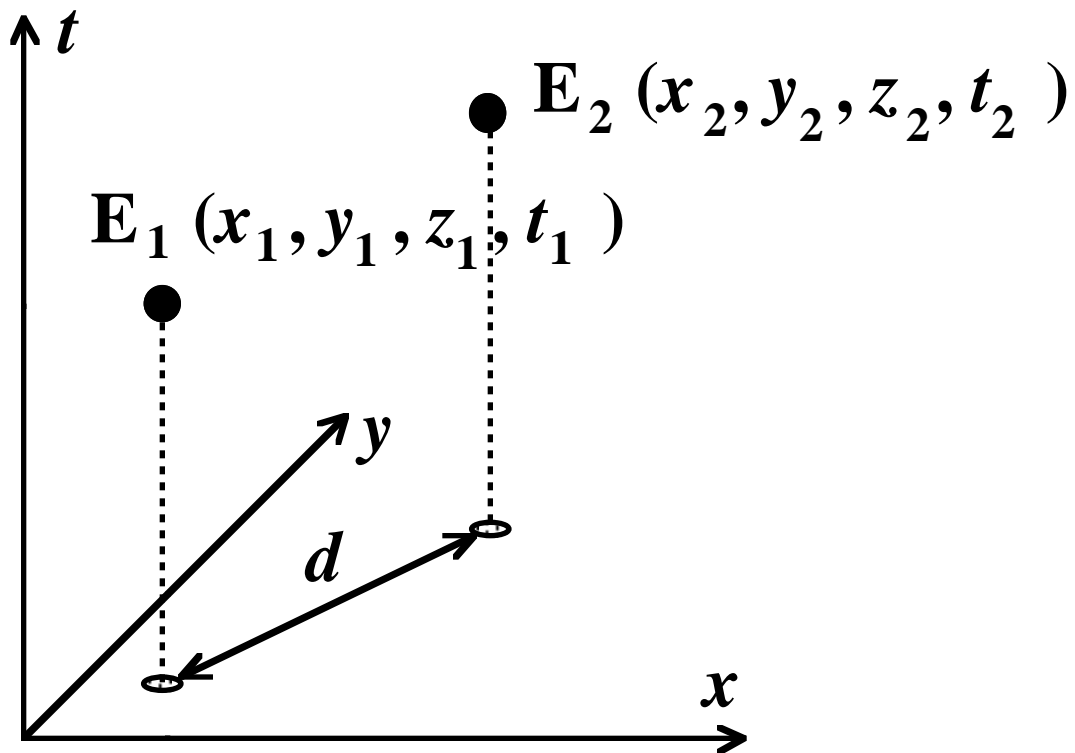
Do the two events occur at the same time?

☞ Two events occur at the same time iff $t_1 = t_2$



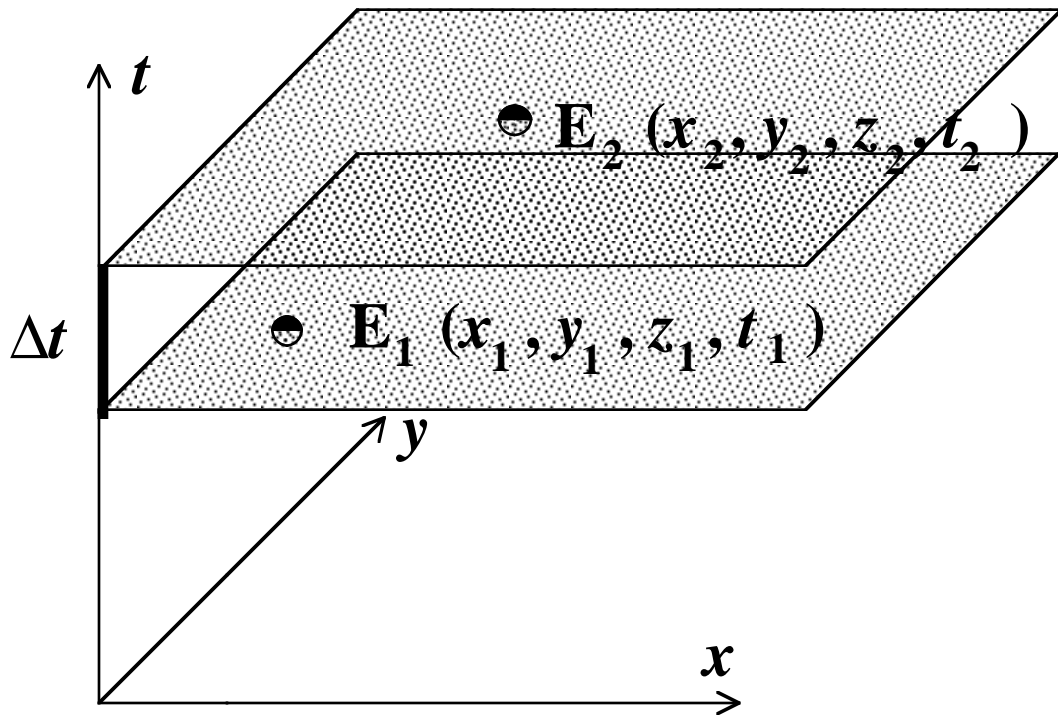
What is the distance d between the two events?

☞ $d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$

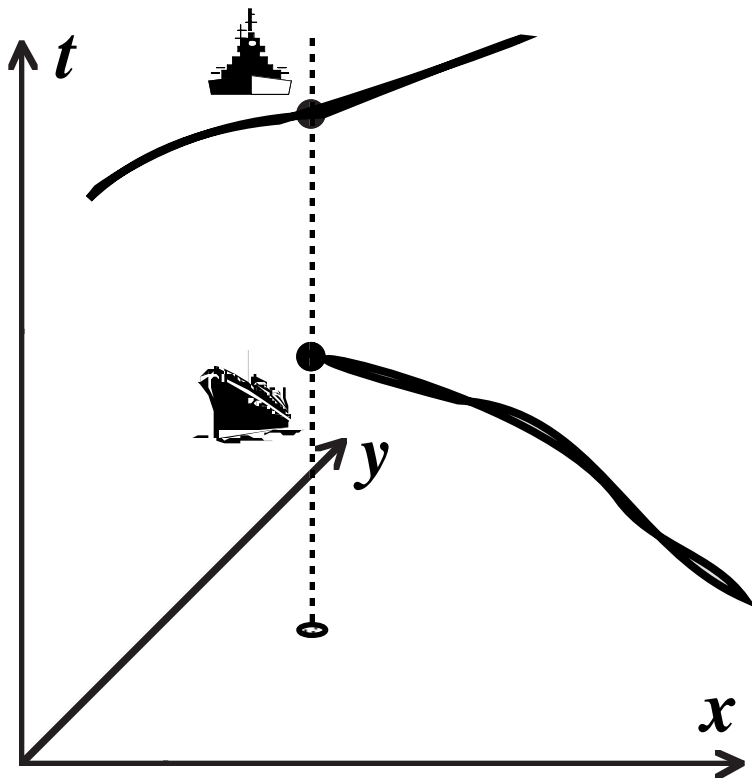


What is the elapsed time between the two events?

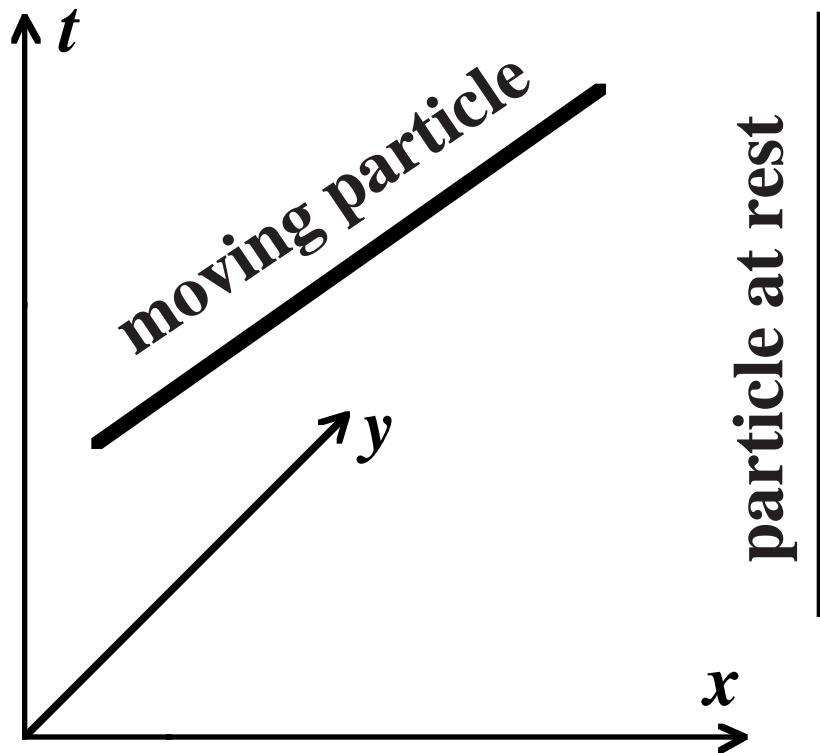
☞ $\Delta t = t_1 - t_2$



☞ “We are now in the exact position where the Titanic sank.”



Particles in Space-Time



Is this particle at rest?

What distance did this particle travel between two moments of time?

What is the speed of the particle?

☛ All make sense in the Aristotelian space-time.

- At each instant of time, consider the event “the particle at that instant.” Associate a position in space with that event, by the usual Aristotelian procedure (i.e., invoke observers with badges, etc.).
- “The particle at all times” = the world-line of the particle
- The world-line of the particle completely describes everything there is to know about its whole life career, or history.

Do the two events have the same position in space?

Do the two events occur at the same time?

What is the distance d between the two events?

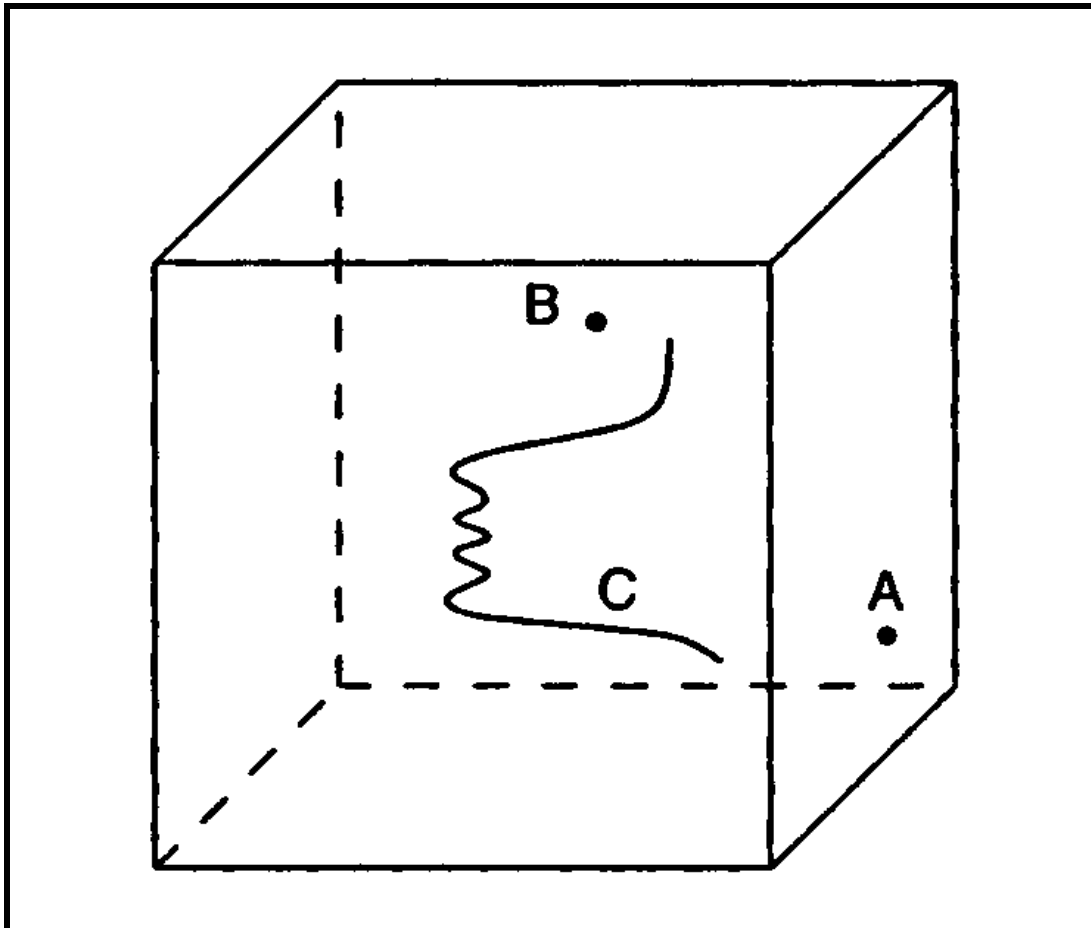
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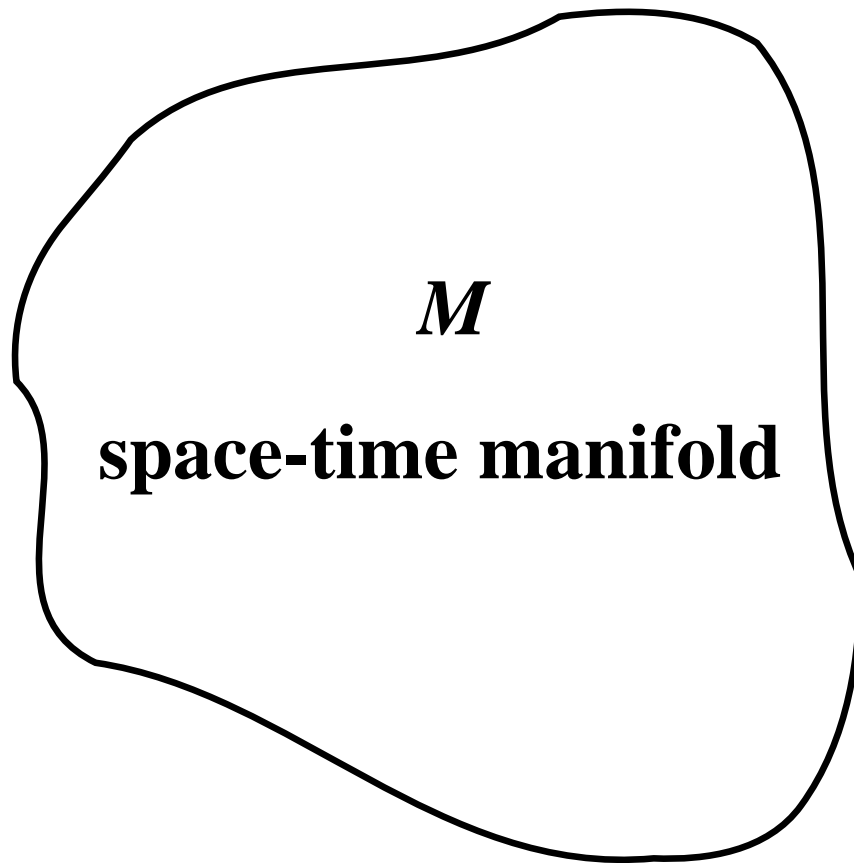
☞ M = space-time
= the space-time manifold
= the set of all possible events in the universe: past present, and future.



“Block Universe”

- A: The fall of Constantinople
- B: The accession of Elizabeth I
- C: Columbus' voyage to America in 1492

[Storrs McCall, *A Model of the Universe*. Oxford 1994, p. 2]



This course is about the *internal structure* of M , that is, about the relationships between (and among) events in space-time.

Everything physically important that happens in our world can be cashed out in terms of the internal relationships imposed on the points of M .

Aristotelian framework, or set-up, is our first attempt to impose a certain system of relationships on M .