

# GR notes

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## Contents

<b>1</b>	<b>Special Relativity</b>	<b>2</b>
1.1	4-Dimensional Spacetime . . . . .	2

## Conventions

1. Greek index (e.g.  $\alpha, \beta, \mu, \nu$ ) take value from  $\{0, 1, 2, 3\}$ .
2. Events denoted by cursive capitals (e.g.  $\mathcal{A}, \mathcal{B}, \mathcal{E}$ ).
3.  $(x^0, x^1, x^2, x^3) \equiv (t, x, y, z) \equiv x^\alpha$
4. Latin index (e.g.  $i, j, k$ ) take value from  $\{1, 2, 3\}$ .
5. New unit that speed of light  $c = 1$

# 1 Special Relativity

## 1.1 4-Dimensional Spacetime

### Definition 1.1. Inertial coordinate

The coordinate system must satisfy three property to be consider inertial coordinat:

1. The distance between two points are independent of time.
2. The clocks at every points ticking off time coordinate  $t$  at same rate.
3. The geometry of space is always Euclidean (flat).

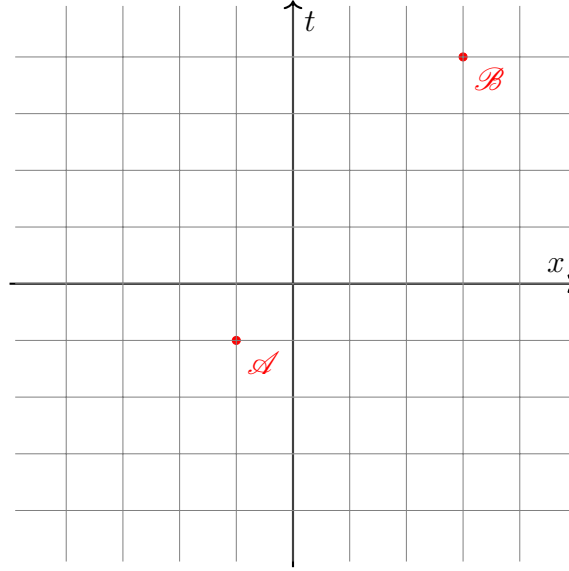


Figure 1: two events with coordinate  $(-1, -1, 0, 0)$  and  $(4, 3, 0, 0)$ .

The event in 4-D spacetime is define by a set of coordinate  $(t, x, y, z)$ . For simplicity, we assume those events have  $y = 0, z = 0$  so that we can draw a 2D graph to represent them.

Analog to Euclidean geometry, just like the euclidean distance  $\Delta l^2 = \Delta x^2 + \Delta y^2 + \Delta z^2$ , we define the **spacetime interval**  $\Delta s = -\Delta t^2 + \Delta x^2 + \Delta y^2 + \Delta z^2$ .

**Remark.** There are a lot different conventions to define the sign of interval, here we just use the popular one  $(-, +, +, +)$ .

### Example.

Interval for the two events in Figure 1 is  $\Delta s = -\Delta t^2 + \Delta x^2 + \Delta y^2 + \Delta z^2 = -9$ .