Today

I. Last Time

II. Remaining Logistics

III. Deriving consequences of the two postulates

I. Explored Einstein's velocity addition law:

$$v_{AC} = \frac{v_{AB} + v_{BC}}{1 + \frac{v_{AB} \cdot v_{BC}}{c^2}}.$$

We drew two conclusions: the speed of light is the same no matter what reference frame the light is viewed from. Secondly, this change in velocity addition has a very small quantitative impact at low speeds.

Special relativity is founded on Einstein's two postulates:

1. Principle of relativity.
2. Universal speed of light.

Which detector fires first?

(A) According to an observer on the train?

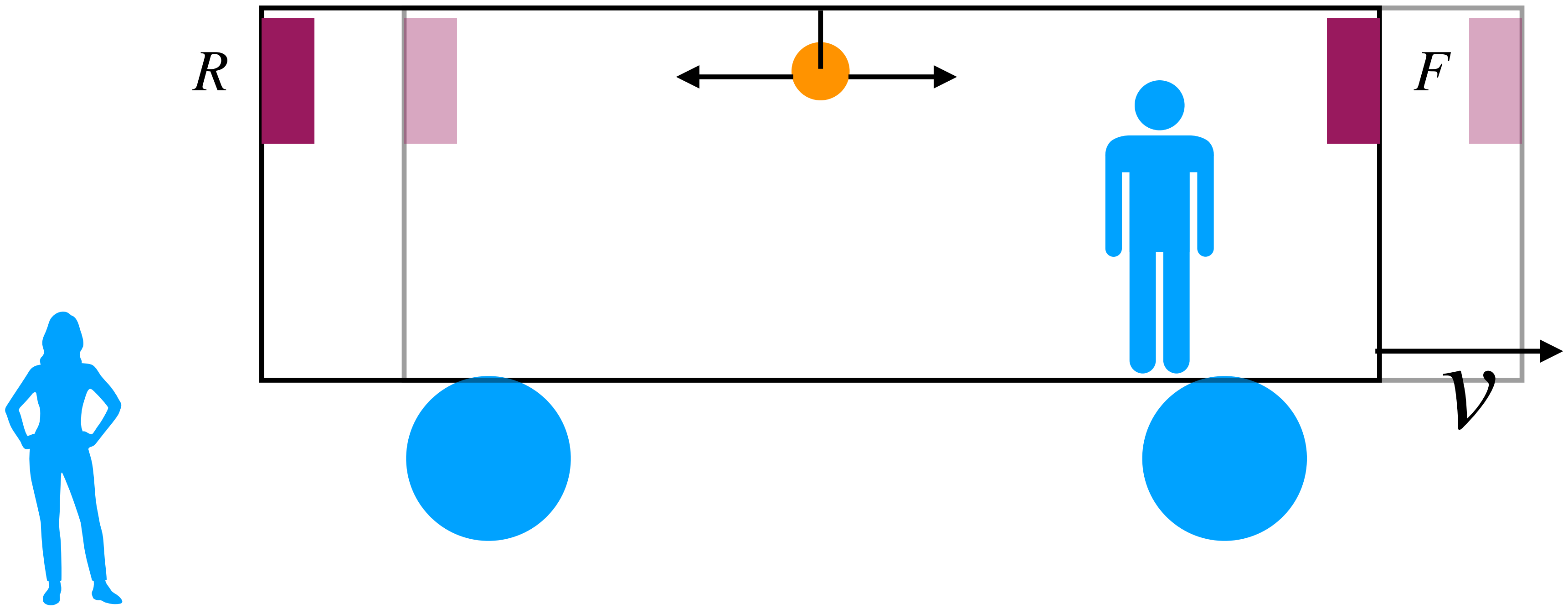
R and F fire simultaneously.

(B) According to an observer on the ground?

R fires first and F second.

The fact that they disagree has massive consequences. There is no universal notion of simultaneity!!!

Conclusion: (1) Two events simultaneous to one (inertial) observer, may not be to another.

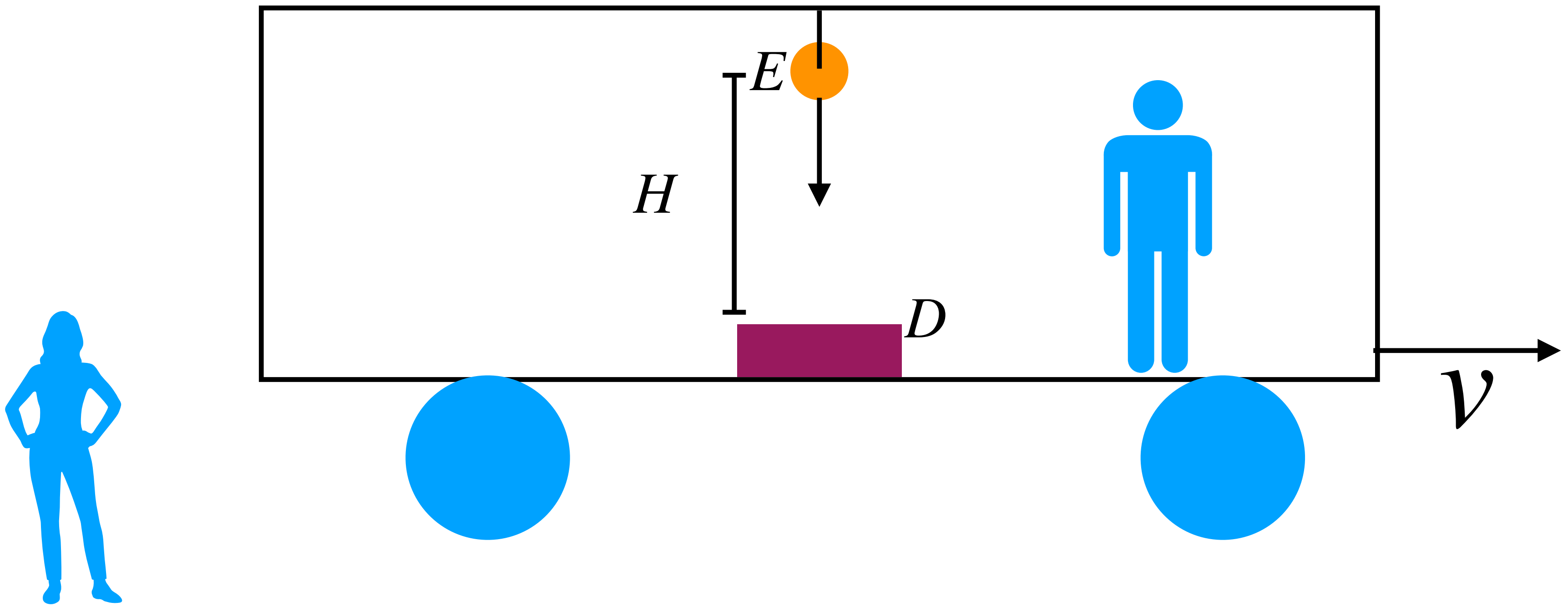


An observation: What you get after correcting for how long the message took to reach you. You could think of a f"custodian" attached to each reference frame.

II. (2) Time Dilation: How long between E and D?

(A) Observer on train: $\Delta t' = \dfrac{H}{c}$.

(B) Observer on the ground:



II. (2) Time Dilation: How long between E and D?

(A) Observer on train: $\Delta t' = \dfrac{H}{c}$.

(B) Observer on the ground:

$$\Delta t = \frac{\sqrt{H^2 + v^2 \Delta t^2}}{c}.$$

Now, let's solve for Δt: $c^2 \Delta t^2 = H^2 + v^2 \Delta t^2$

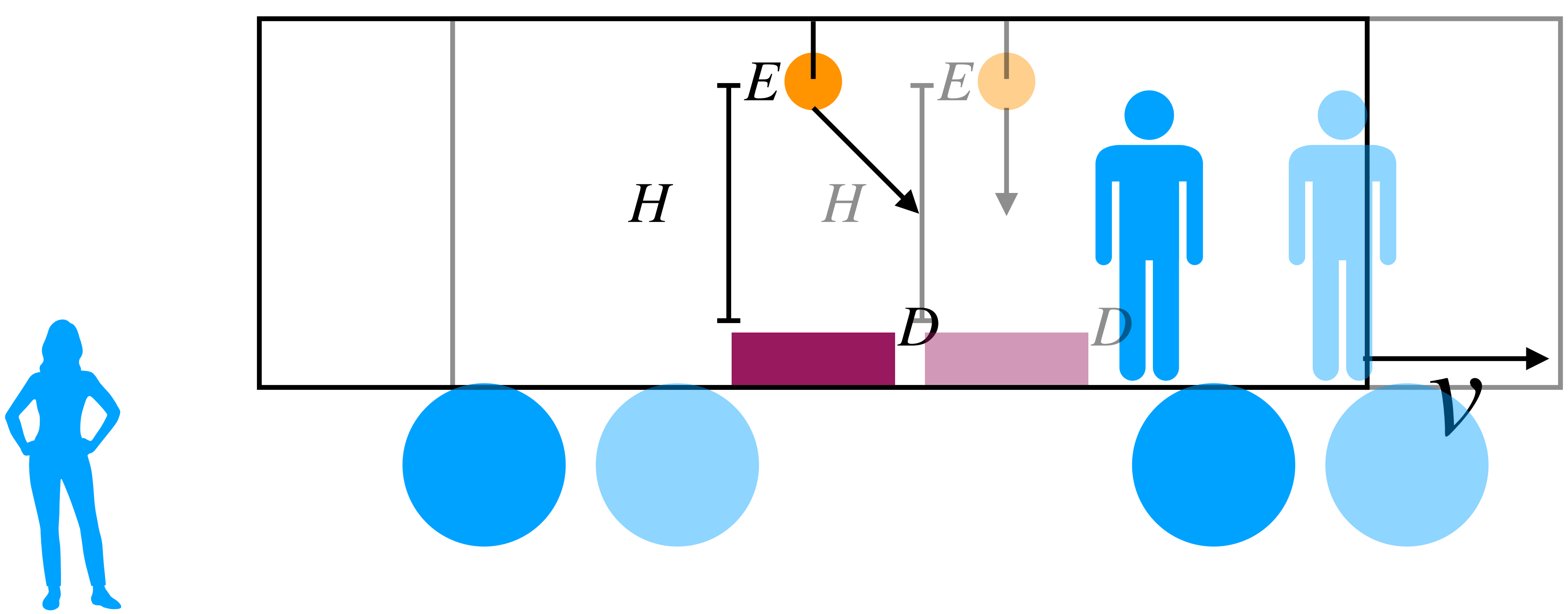
$$(c^2 - v^2)\Delta t^2 = H^2$$

$$\left(1 - \frac{v^2}{c^2}\right)\Delta t^2 = \frac{H^2}{c^2} \implies \Delta t = \gamma \frac{H}{c} = \gamma \Delta t'$$

We always say that "Moving clocks run slow".

$$\gamma \equiv \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \geq 1$$

Slow means they have fewer clicks. In other words, you age more slowly when you are moving.



An example: $v = \frac{3}{4}c$, then $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{9}{16}}} = \frac{1}{\sqrt{\frac{7}{16}}} = \frac{4}{\sqrt{7}}$

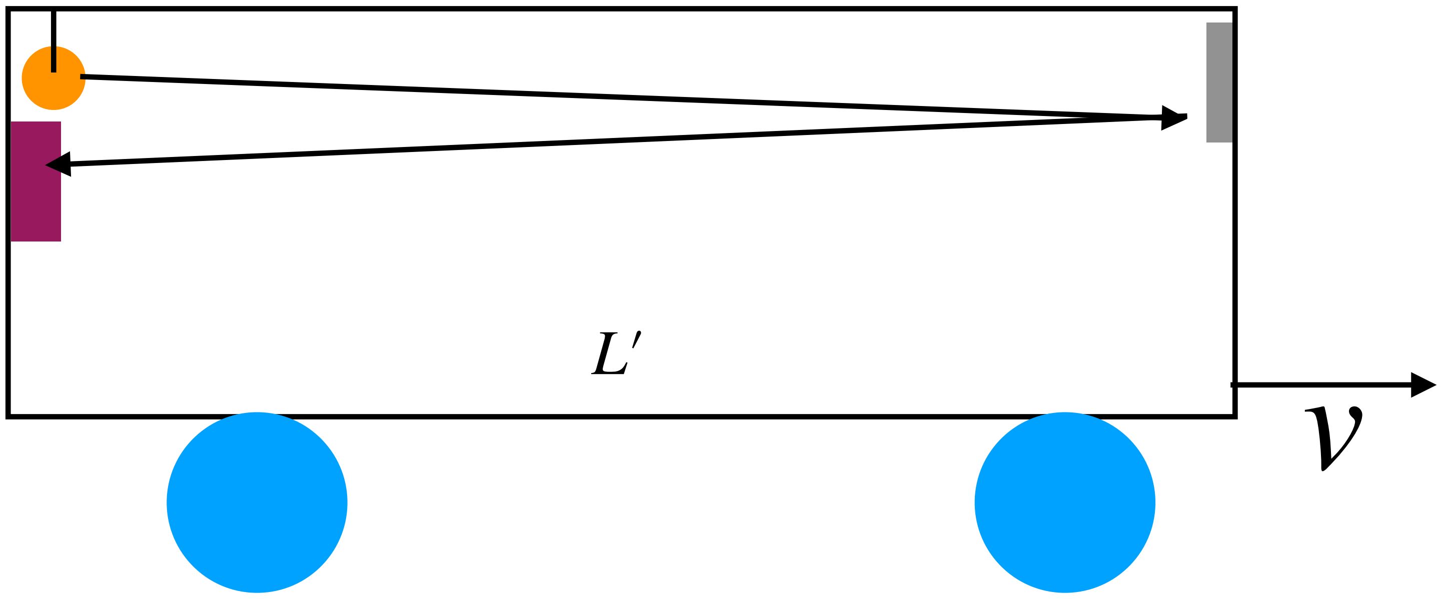
So, $\gamma \approx 1.5$, and after one second according to the train observers, a ground observer will measure 1.5 seconds.

(3) Length Contraction (Lorentz Contraction): Again we'll use a train experiment.

Question: How long does the round trip take?

(A) On train;

$$\Delta t' = \frac{2L'}{c}$$



(3) Length Contraction (Lorentz Contraction): Again we'll use a train experiment.

Question: How long does the round trip take?

(A) On train;

$$\Delta t' = \frac{2L'}{c}$$

(B) On ground; The forward trip time is $\Delta t_1 = \dfrac{L' + v\Delta t_1}{c}$