Modern Physics

Day 1

Outline

0. Review Syllabus

I. Special Theory of
   Relativity

I. Theory of Space &
   time (Einstein 1905)

Einstein's Two Postulates

(1) Principle of Relativity: The
laws of physics apply just as
well in a moving system as
in one at rest.

In a train car m?
expmts just the same as at
rest.

Embarrassing implication:
no such thing as "rest system"
∴ 1st postulate

Def: An inertial reference
frame is one in which

(2) Universal Speed of Light:
The speed of light (in vacuum) is
the same (3×10⁸ m/s) regardless
(of the motion of its source, or the
observer).

(1) Princ. of rel. Old stuff
(Galileo said it.)

Newton's 1st law (the law of inertia) holds.

(1') The ordinary laws of physics apply in any inertial frame.

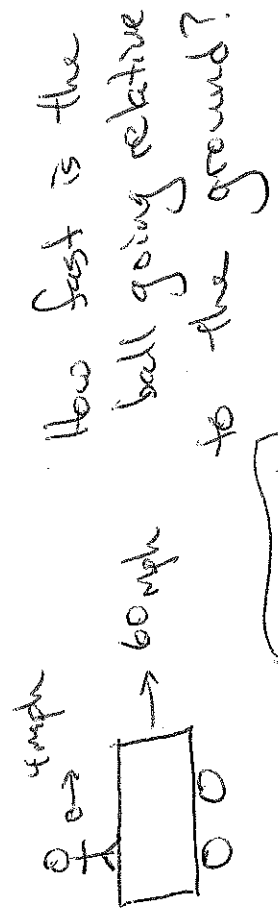(2') Speed of light is the same for all inertial observers.

Example of 1st postulate P2/4

[6 kg] ↑ ?   After

[2 kg] 3m/s →   [4 kg]
Before
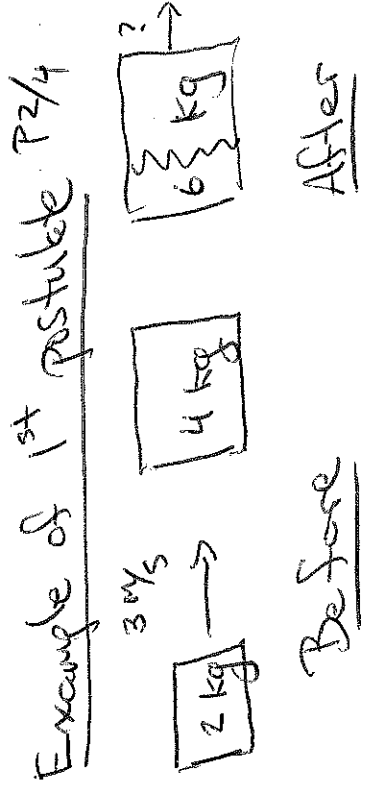
Cons. of momentum:

$2 \cdot 3 \ kg\,m/s = 6 \ kg \cdot v$

$\Rightarrow \boxed{v = 1 \ m/s}$

In frame S' moving at $+3 m/s$

[2 kg] 3m/s →   [4 kg]
Before

[6 kg] ↓ 2m/s
After

Was momentum conserved?

$4(-3) \ kg\,m/s \overset{?}{=} 6(-2) \ kg\,m/s$

Yes!

(2') 2nd Postulate. Revolutionary.

Absurd on its face

[train] 4mph, →60mph

How fast is the ball going relative to the ground?

64mph

Galileo's velocity addition:

$v_{AC} = v_{AB} + v_{BC}$

ball   train   ground

Einstein's velocity addition:

$$V_{AC} = \frac{V_{AB} + V_{BC}}{\left(1 + \frac{V_{AB} \cdot V_{BC}}{c^2}\right)}$$

flashlight

60 mph
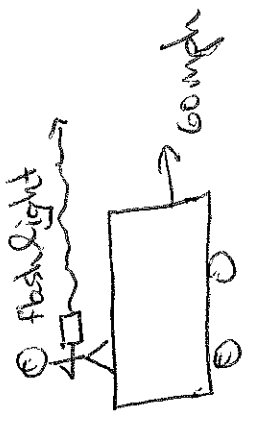
How Einstein's rule saves 2nd postulate.

$$V_{light/ground} = \frac{c + v}{1 + \frac{cv}{c^2}}$$

$$= c \cdot \frac{c+v}{c+v} = c!$$

This is the One of

the first of four

"elementary geometrical"

consequences of the 2

Postulates:

(1) Relativity of Simultaneity

(2) Time dilation

(3) Lorentz contraction
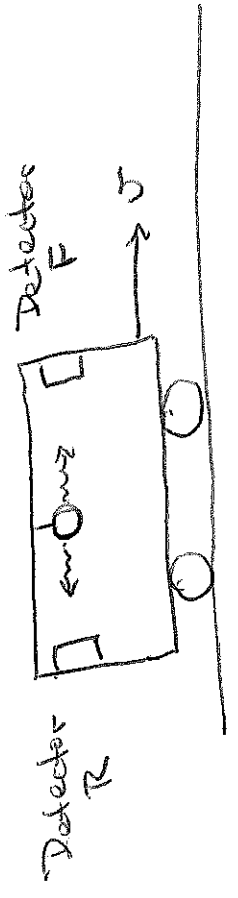
(4) Einstein velocity addition

Let's derive these

(1) Relativity of simultaneity

Def: A event happens at

a particular location at a

particular time.

Detector
R

Detector
F

ν

Which detector

fires first? (R or F)

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

(A) Observer on the train:
R & F simultaneously

(B) Observer on the ground:
R before F.

Conclusion: Two events simultaneous to one (inertial) Observer, may not be to another!