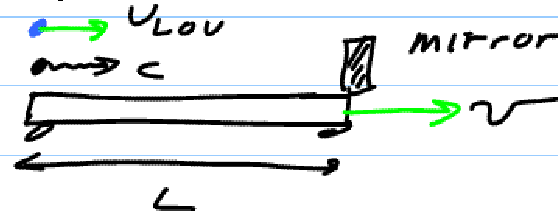
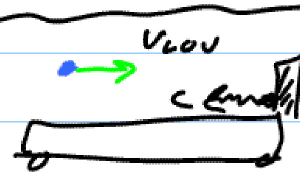
# PHY132S - Relativity
## Class 4 - April 1 2009

§C.6

Lou

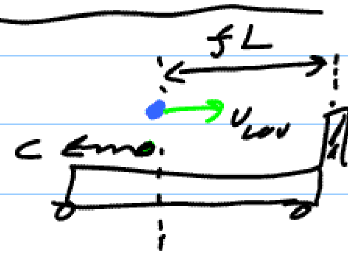



$t_1$




$t_2$

later




they meet $\quad 0 < f < 1$

$$v_{Lou}(t_1 + t_2) = c(t_1 - t_2)$$

$$\begin{cases} ct_1 = L + vt_1 \\ ct_2 = fL - vt_2 \end{cases}$$

$$\frac{t_2}{t_1} = \frac{(c - v_{Lou})}{(c + v_{Lou})}$$

$$f_{LOU} = \frac{(c+v)}{(c-v)} \times \frac{t_2}{t_1}$$

$$f_{LOU} = \frac{(c+v)}{(c-v)} \times \frac{(c - U_{LOU})}{(c + U_{LOU})}$$

SUE: stationary wrt train

$$f_{SUE} = \frac{(c - U_{SUE})}{(c + U_{SUE})}$$

$$f_{LOU} = f_{SUE}$$

$$\rightarrow \quad U_{SUE} = \frac{U_{LOU} - v}{(1 - U_{LOU} v / c^2)} \Leftarrow$$

Numerator: common sense result

Lou stationary wrt air

$U_{LOU} = 343$ m/s

You: $0.99 \times 343\,m/s$ wrt air
$= 340\,m/s = v$

$U_{YOU} \cong (343 - 340) = 3\ m/s$
Just numerator!

$U_{YOU} - (U_{LOU} - v) = 4.43 \times 10^{-12}\,m/s$

correct — common sense

$U_{LOU} = c$

$$U_{SUE} = \frac{U_{LOU} - v}{1 - U_{LOU}\,v/c^2}$$

$$= \frac{c - v}{1 - cv/c^2} = c$$

If Sue moves to left.
$v \to -v$

§37.9

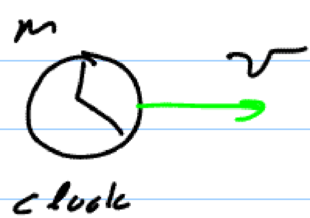
## Momentum

$$U_{SVE,B} = \frac{U_{LOV} - v}{(1 - U_{LOV}\, v/c^2)}$$

$$v = -U_{LOV}$$

$$\left[\; U_{SVE,B} = \frac{2\,U_{LOV}}{(1 + U_{LOV}^2/c^2)} \;\leftarrow \right]$$

Something is weird about momentum!




$$\vec{p} = m \frac{\overrightarrow{\Delta x}}{\Delta t}$$

↗ which time?

Choose $\Delta\tau$

$\Delta\tau$ "rest time"

observer at rest wrt clock

$$\vec{p} = m \frac{\overrightarrow{\Delta x}}{\Delta \tau}$$

$$\Delta t_{ME} = \frac{1}{\sqrt{1 - v^2/c^2}} \Delta \tau$$

$$\vec{p}_{ME} = \frac{1}{\sqrt{1 - v^2/c^2}} m \vec{v}$$

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$\Delta \vec{p} = \int \vec{F} dt = \vec{J} \equiv \text{impulse}$$

$v = c \qquad |\vec{J}| = \infty$

c: nature's speed limit.

§37.10

$(c\Delta t)^2 - (\Delta x)^2$ invariant

$\Rightarrow (\gamma m c^2)^2 - (p)^2 =$ invariant

?

UNITS! J

MAT 135 § 11.11

$(1+x)^n \cong 1 + nx$ x small

$\gamma mc^2 \cong mc^2 + \frac{1}{2}mv^2$

$$E = \frac{1}{\sqrt{1-v^2/c^2}} mc^2$$

$v = 0$ "rest energy" $E_0 = mc^2$

$K = E - E_0$

Mass & Energy are equivalent!

Example!

positron $e^+$
identical to electron
but $q = +e$, not $-e$

electron! $e^-$

⊙ $e^+$ formed with an $e^-$
"pair production"

light E causes pair production

Conversion of E to m

⊙ $e^+$ collides with $e^-$
both annihilate.
mass → light energy