

Title: Special Relativity 13 - Artificial Gravity Provides Hints about Real Gravity

Date: Jul 27, 2008 09:00 AM

URL: <http://pirsa.org/08070051>

Abstract: Analyzing the artificial gravitational field inside a rotating cylinder to discover hints about the nature of real gravitational fields.

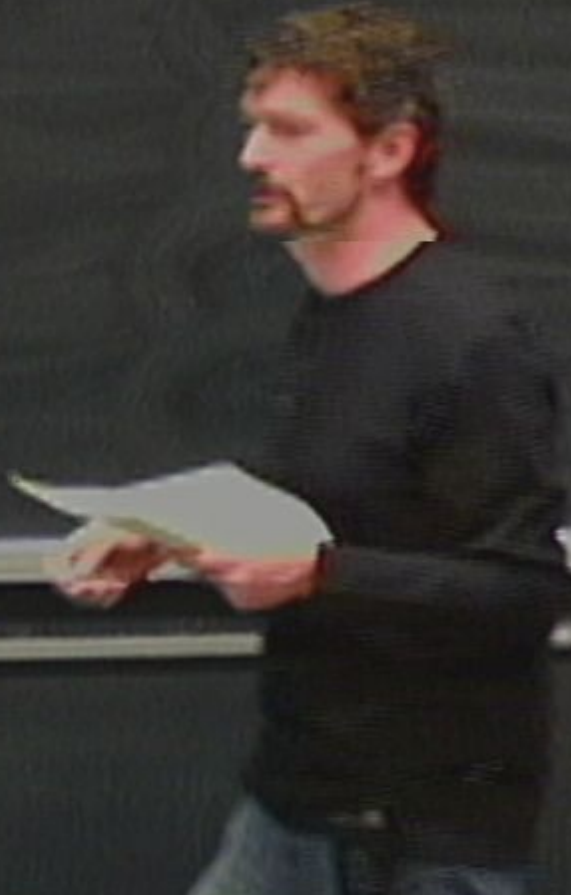
Learning Outcomes:

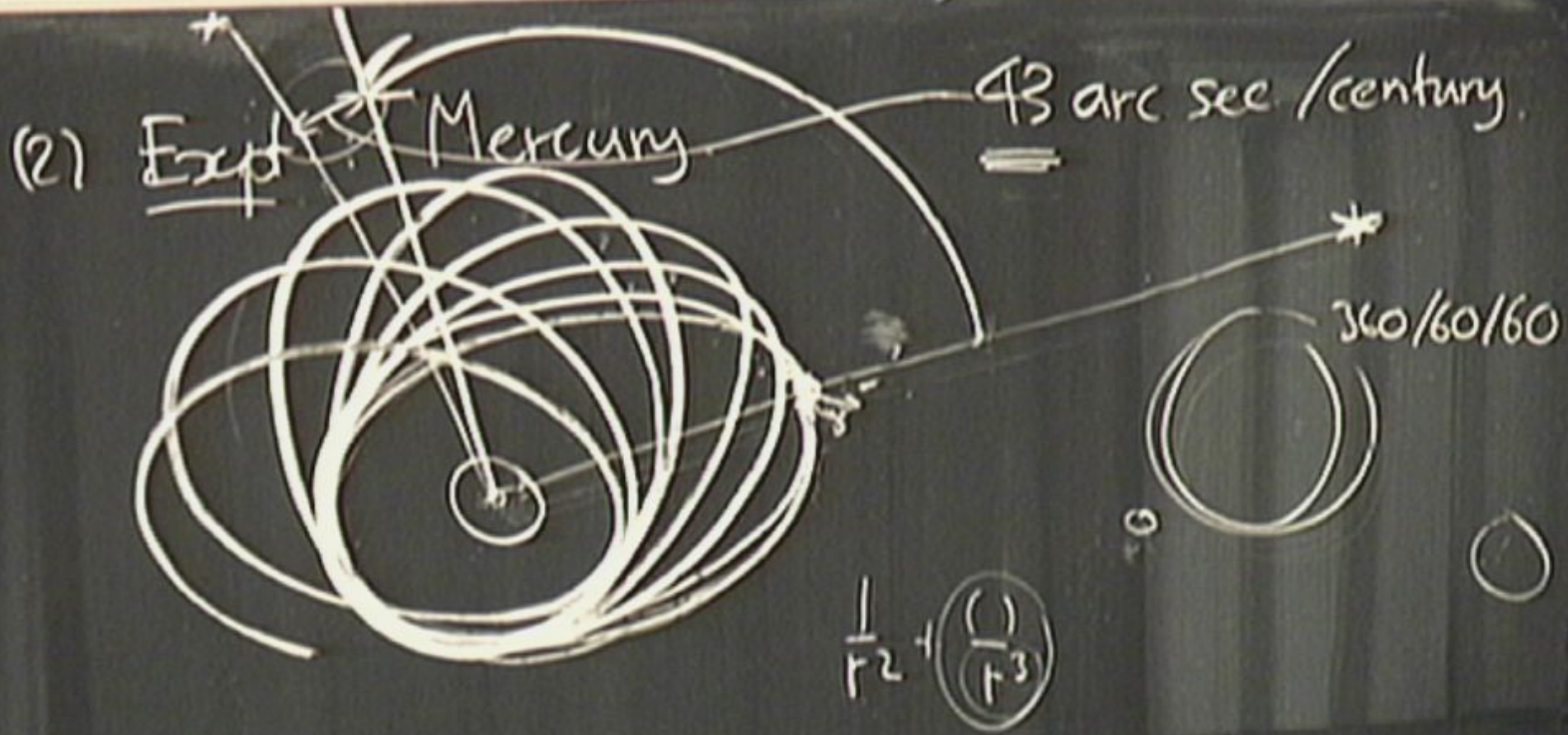
â€¢ How to compare relativistic effects of an accelerated observer who is inside the rotating cylinder to observers at rest in the inertial reference frame outside the rotating cylinder.

â€¢ Understanding that the relative time dilation effect decreases as the rotating observer moves toward the axis of rotation, and how this suggests that a real gravitational field might warp time.

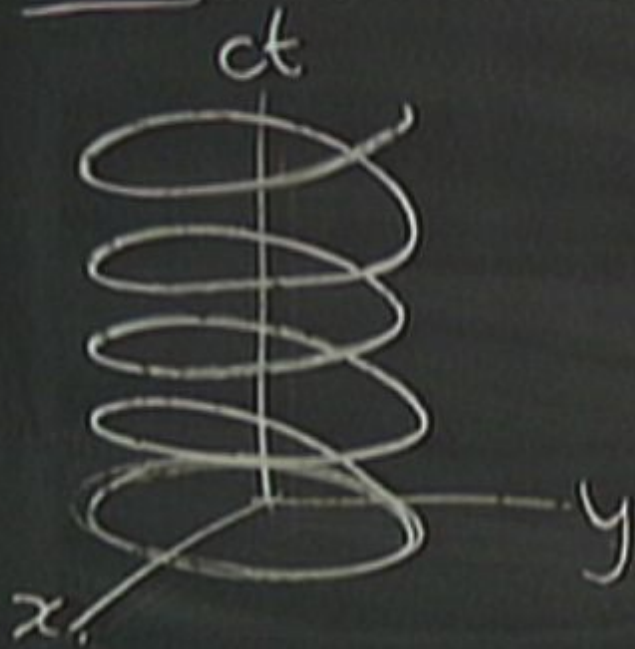
â€¢ Understanding that the circumference of the cylinder as measured by the rotating observers increases, and how this suggests that a real gravitational field might warp space.

Idea: Analyze artificial grav. for hints about real grav.

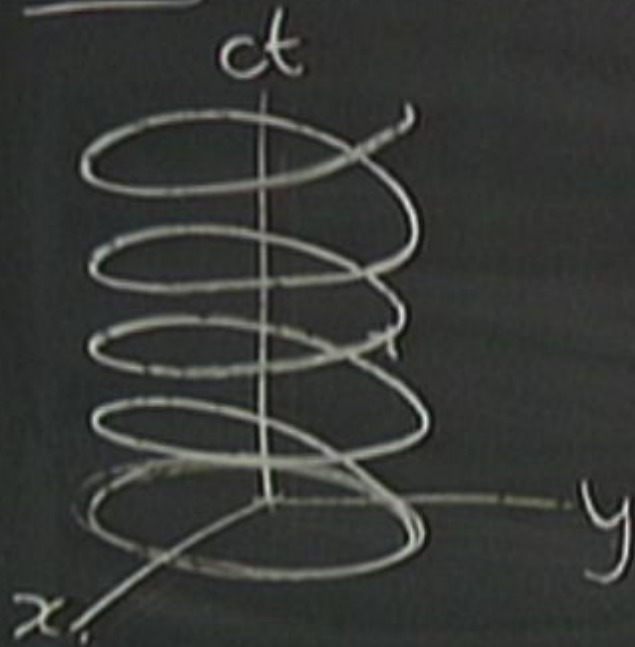




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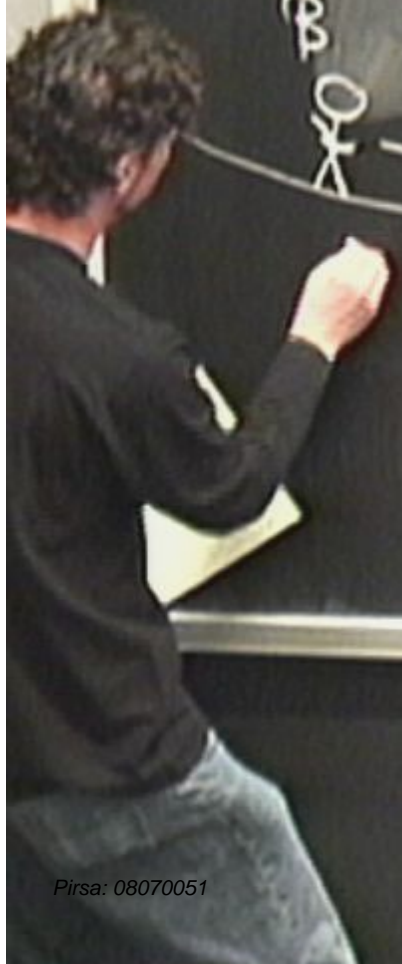


Time Dilation

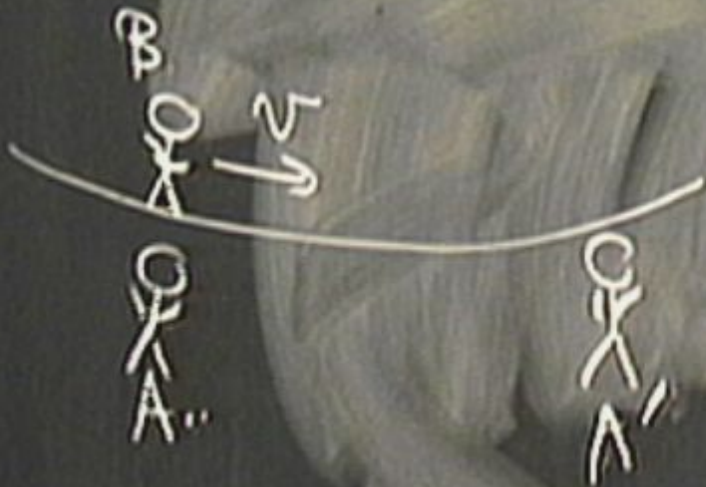


Time Dilation

β
 γ
 \downarrow

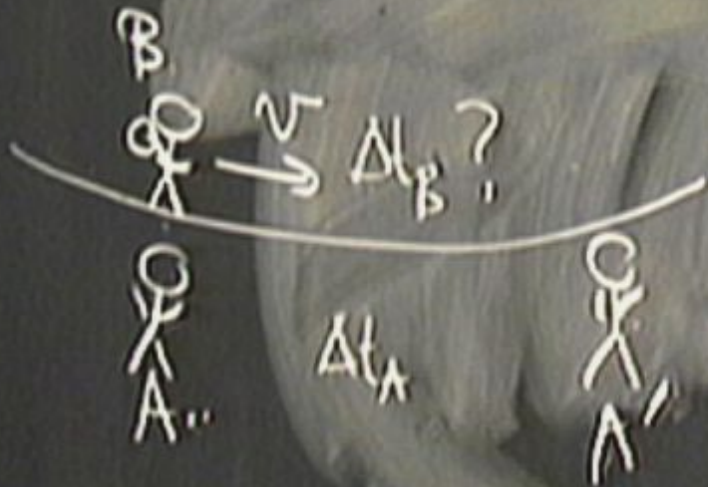


Time Dilation



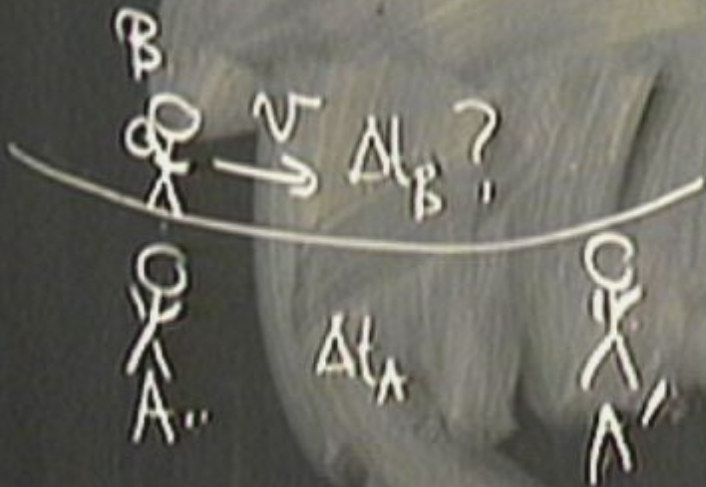
Time Dilation

$$\Delta t_B =$$

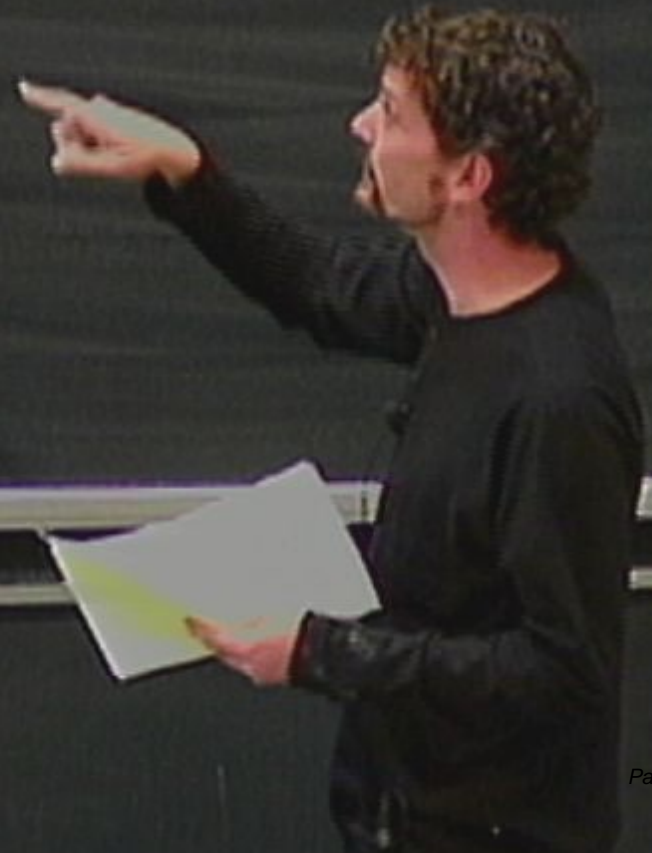
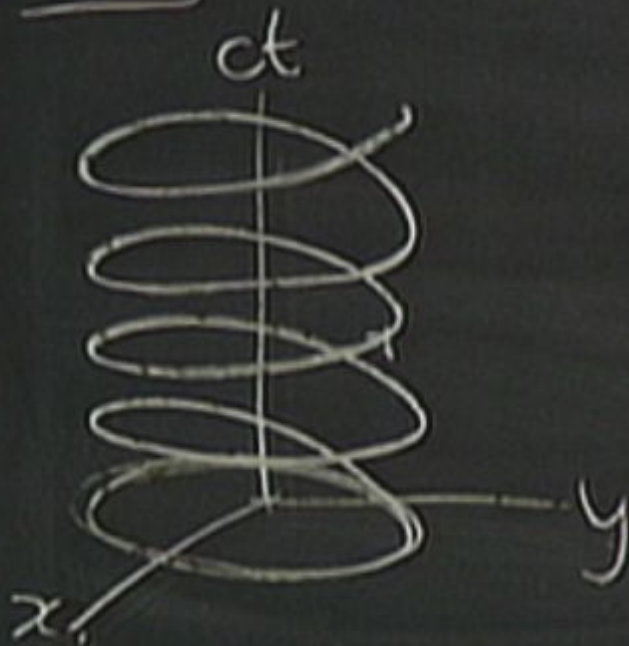


Time Dilation

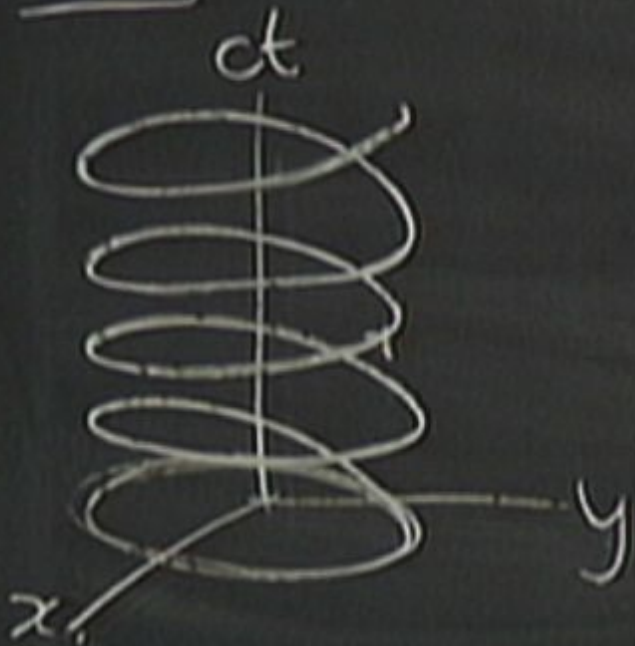
$$\Delta t_B = \sqrt{1 - v^2/c^2} \Delta t_A < \Delta t_A$$



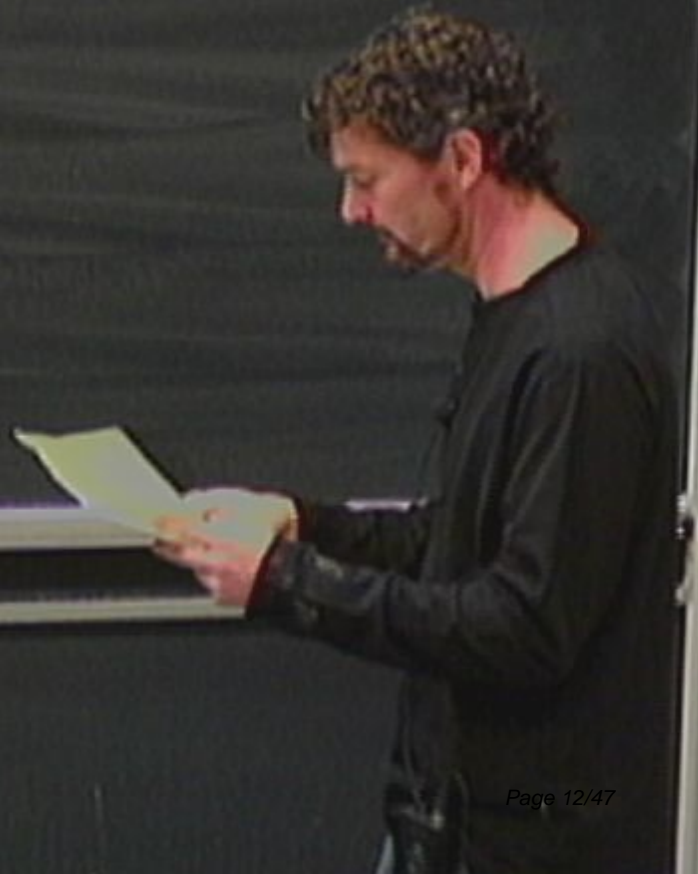
Idea: Analyze artificial grav. for hints about real grav.



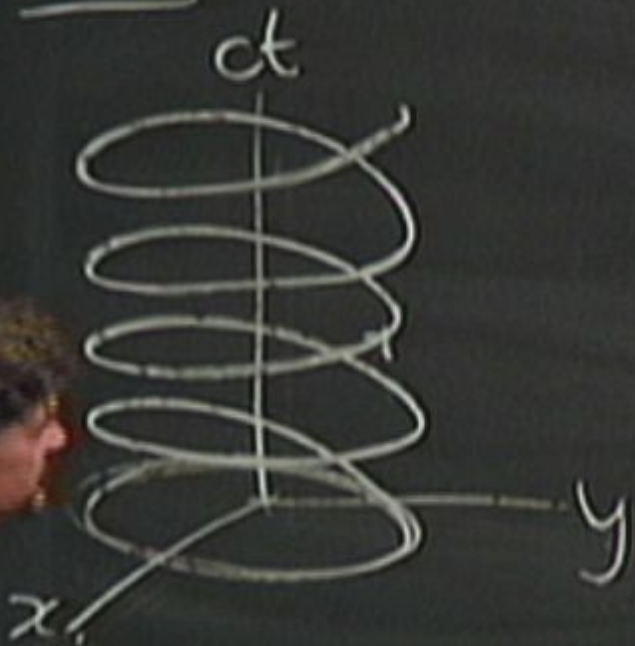
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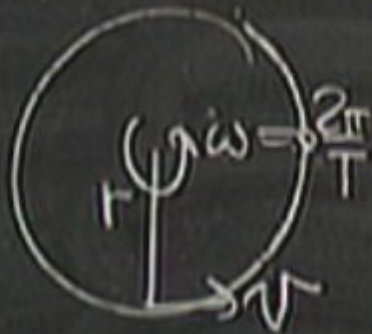
$$"g" = a_c = \frac{v^2}{r}$$



Idea: Analyze artificial grav. for hints about real grav.

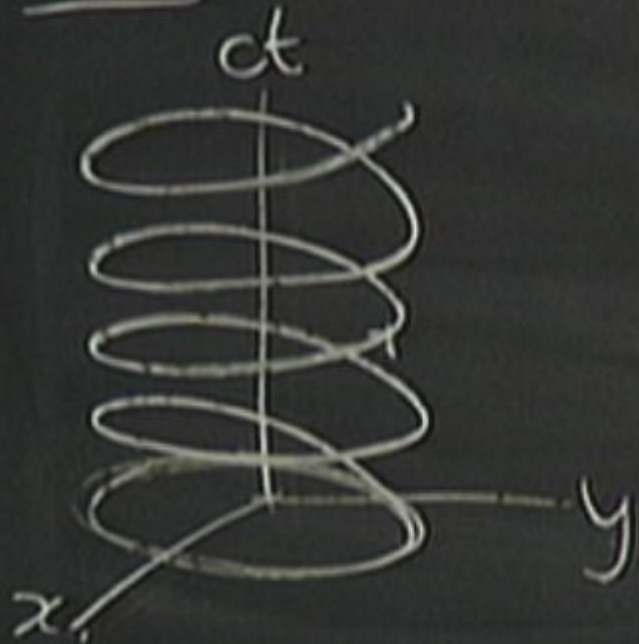


$$"g" = a_c = \frac{v^2}{r^2}$$

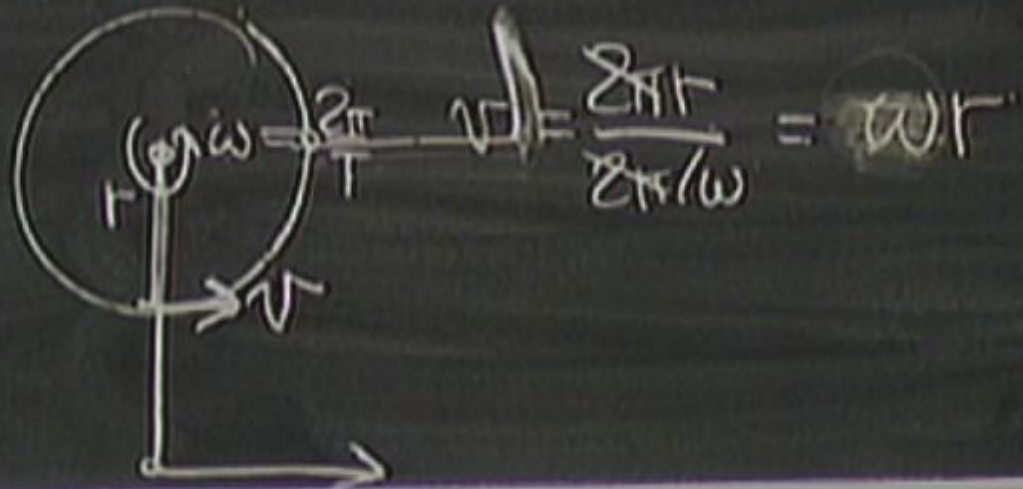


$$v = \frac{2\pi r}{2\pi/\omega} = \omega r$$

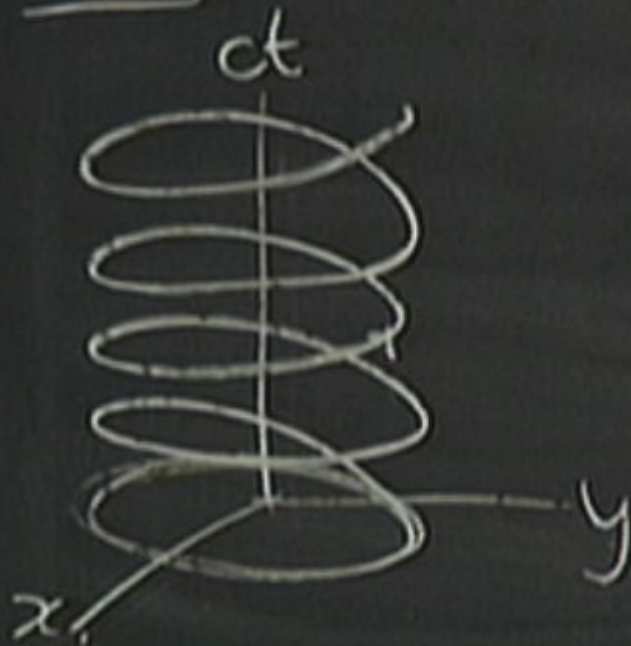
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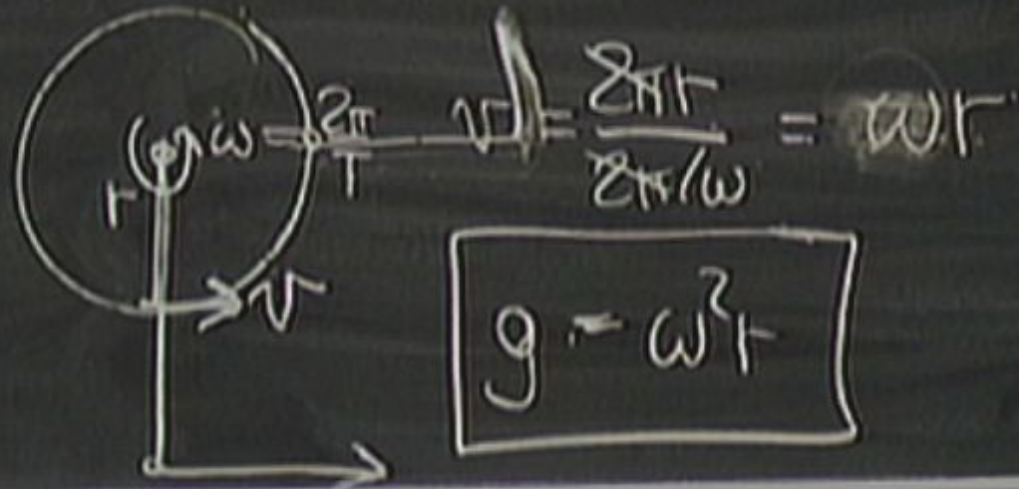
$$"g" = a_c = \frac{v^2}{r}$$



Idea: Analyze artificial grav. for hints about real grav.

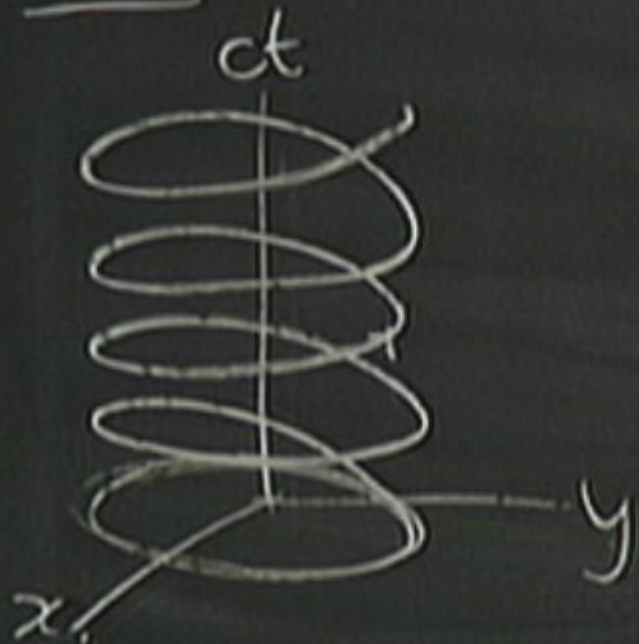


$$"g" = a_c = r\omega^2$$

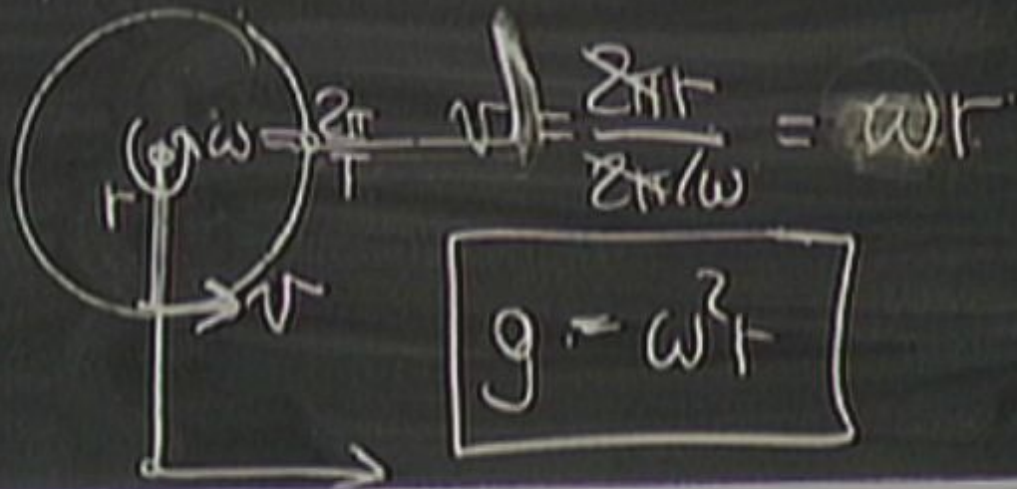


$$g = \omega^2 r$$

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$$"g" = a_c = \frac{v^2}{r}$$

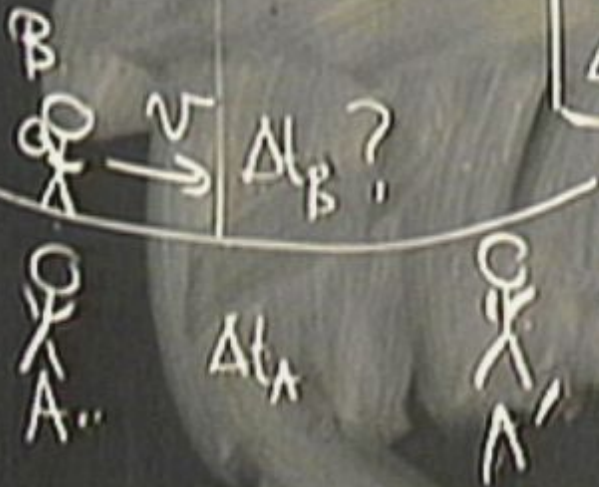


$$g = \omega^2 r$$

Time Dilation

$$\Delta t_B = \sqrt{1 - v^2/c^2} \Delta t_A < \Delta t_A$$

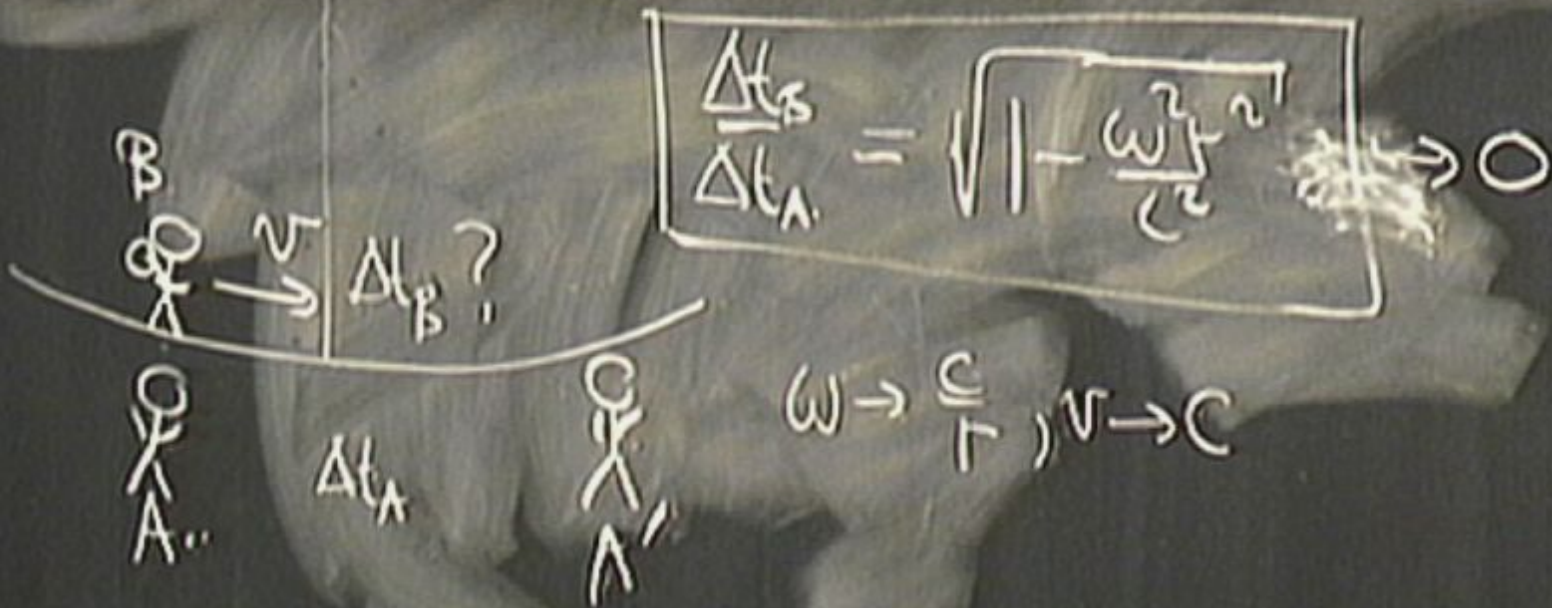
$$\frac{\Delta t_B}{\Delta t_A} = \sqrt{1 - \frac{v^2}{c^2}} \rightarrow 0$$



$$\omega \rightarrow \frac{c}{T}, v \rightarrow c$$

Time Dilation

$$\Delta t_B = \sqrt{1 - v^2/c^2} \Delta t_A < \Delta t_A$$



A

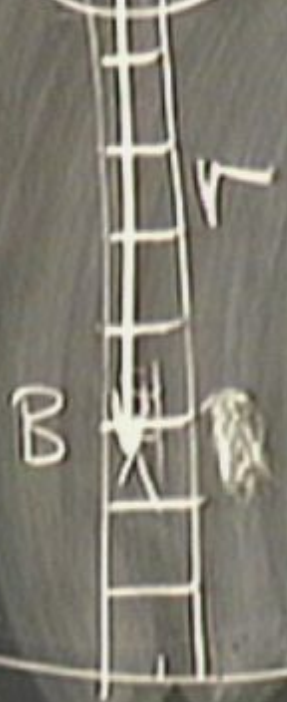


A



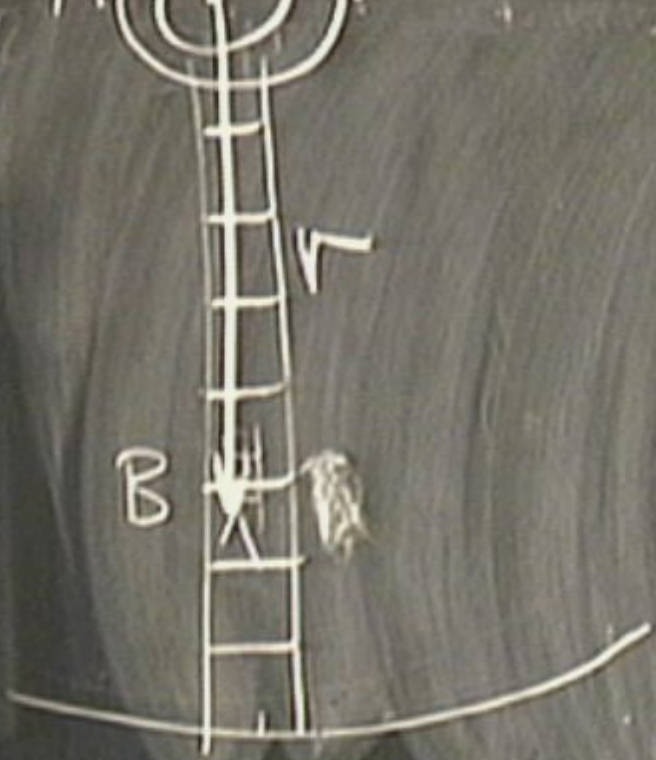
S
X
B





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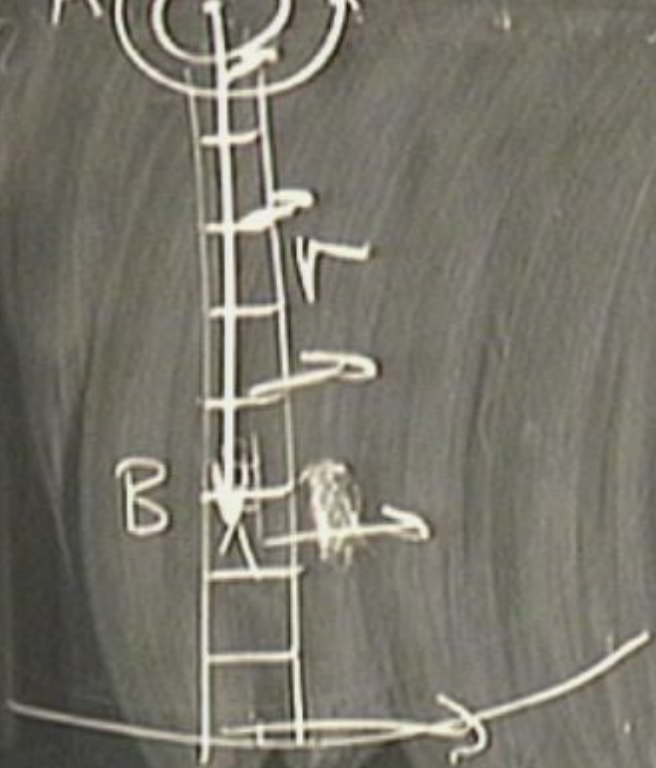
A ω



B

CAUTION
DO NOT TOUCH
EQUIPMENT
WHEN ON

A ω



B



r decreases (climbs against grav.)

→ less slowing

→ time moves faster.



r decreases (climbs against grav.)

→ less slowing

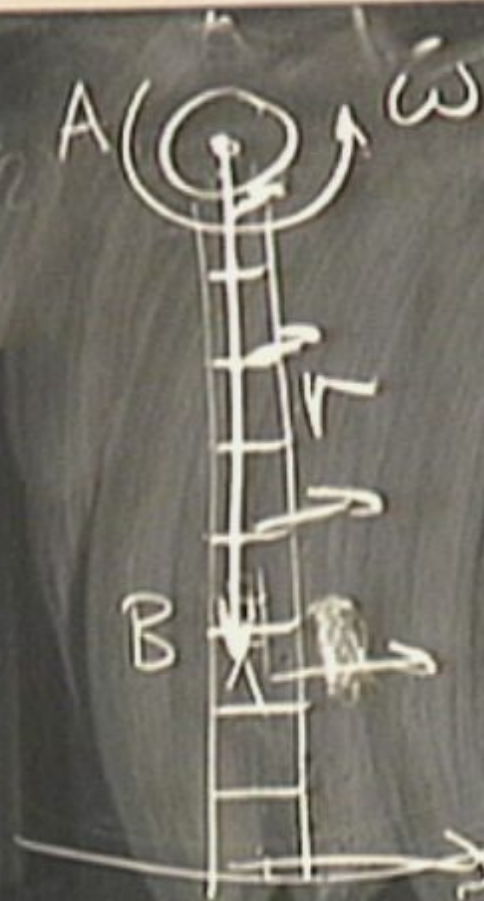
→ time moves faster.



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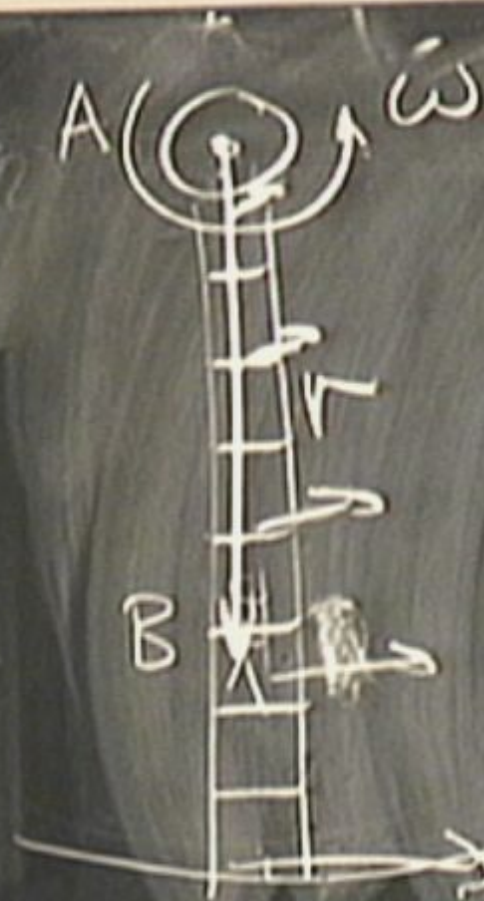


r decreases (climbs against grav.)

→ less slowing

→ time moves faster.

... true of real grav field?



r decreases (climbs against grav.)

→ less slowing

→ time moves faster.



true of real grav field? YES



r decreases (climbs against grav.)

- less slowing
- time moves faster



true of real grav field? YES

Length Contraction

$\beta = 0.8$ $\gamma = 1.667$

$\beta = 0.6$ $\gamma = 1.25$

$\beta = 0.4$ $\gamma = 1.091$

$\beta = 0.2$ $\gamma = 1.02$

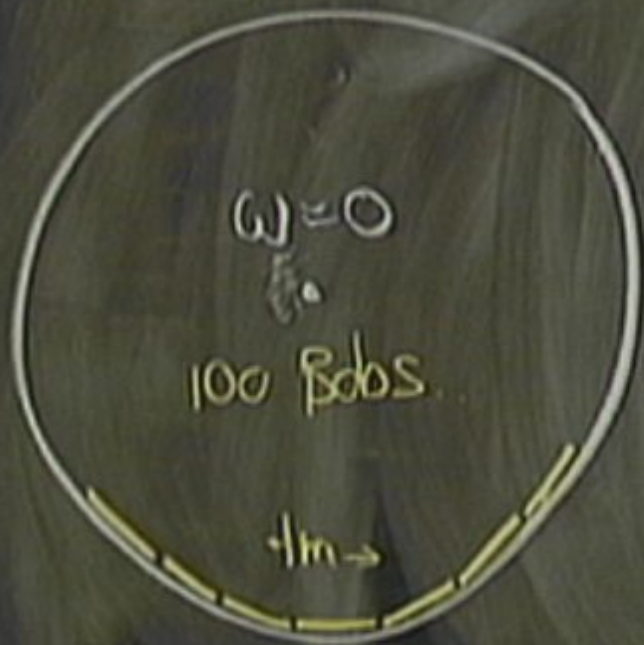
Length Contraction



Length Contraction



Length Contraction

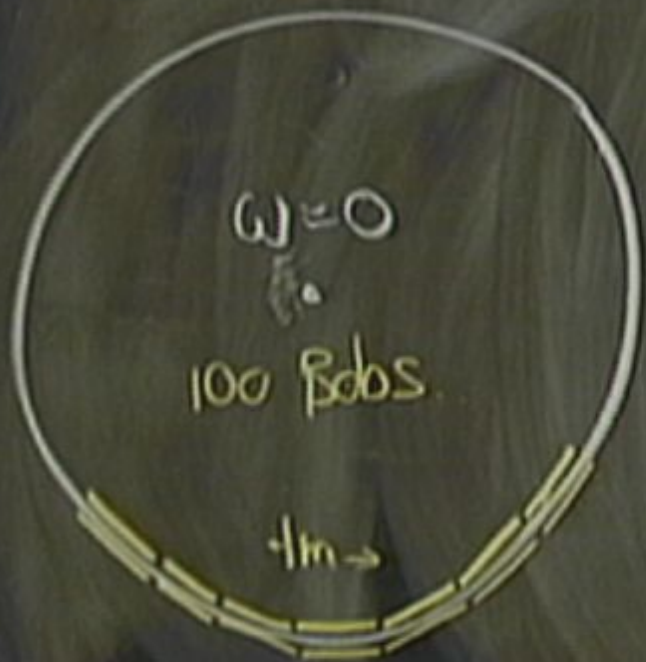


Length Contraction



100
Alices

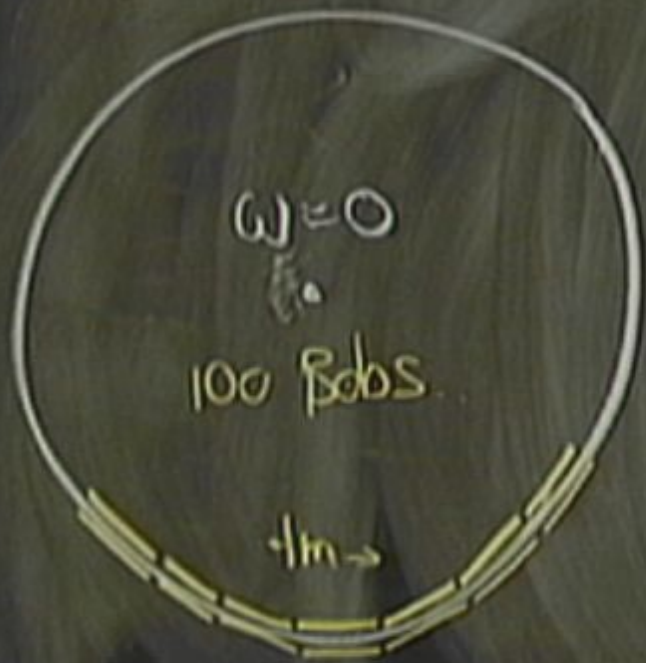
Length Contraction



100
Alices



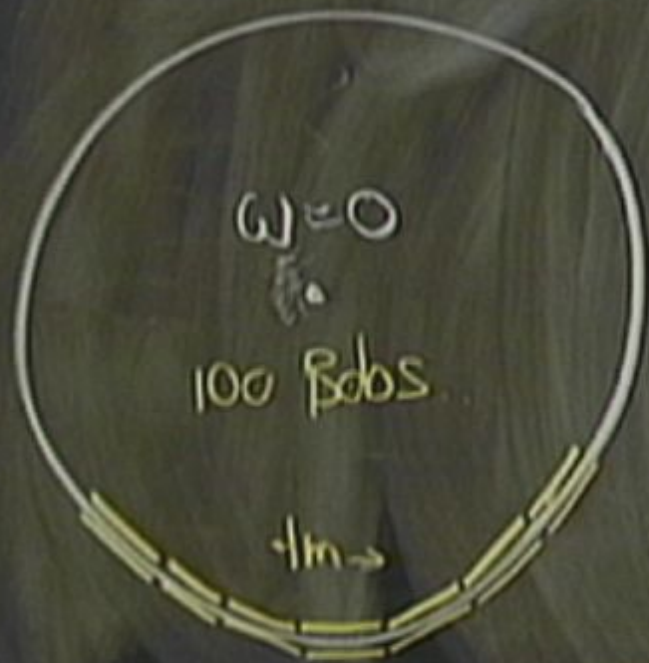
Length Contraction



100
Alikes



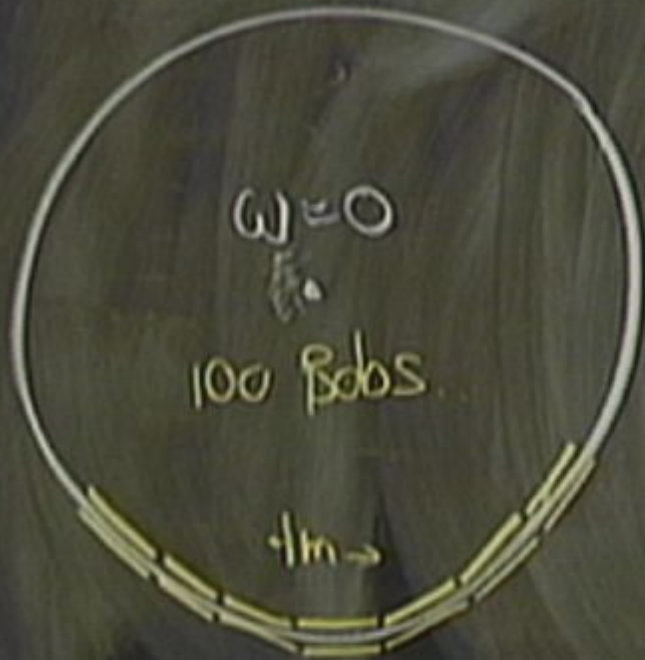
Length Contraction



100
Alices



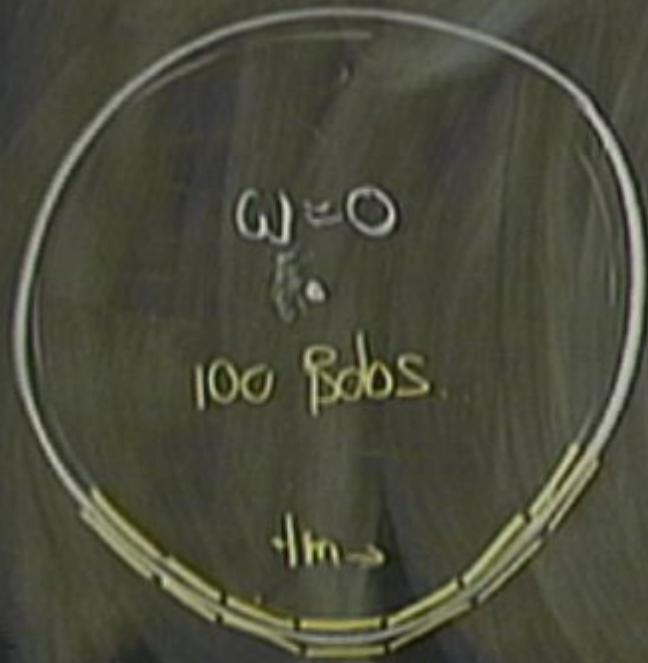
Length Contraction



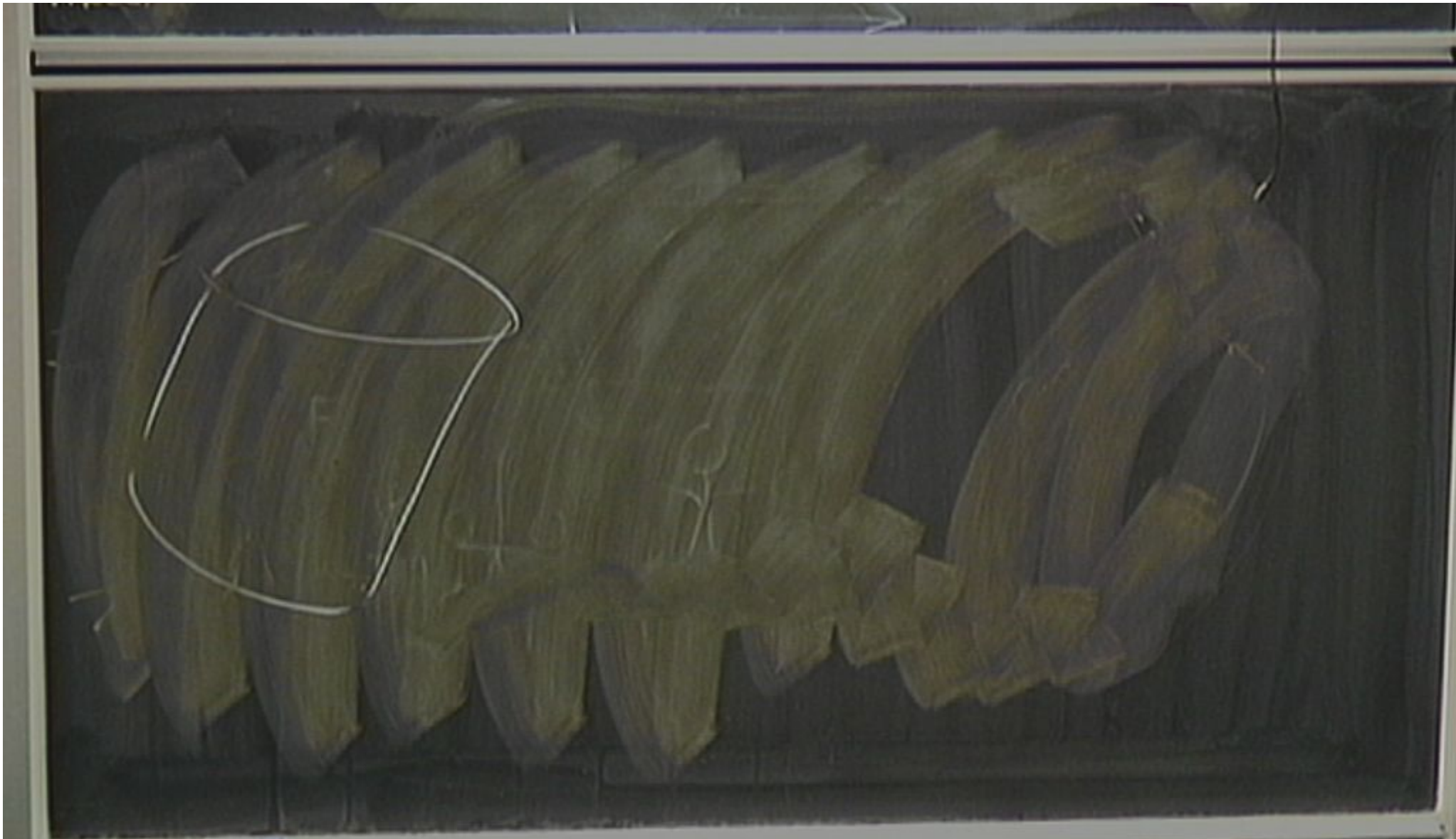
100
Alices

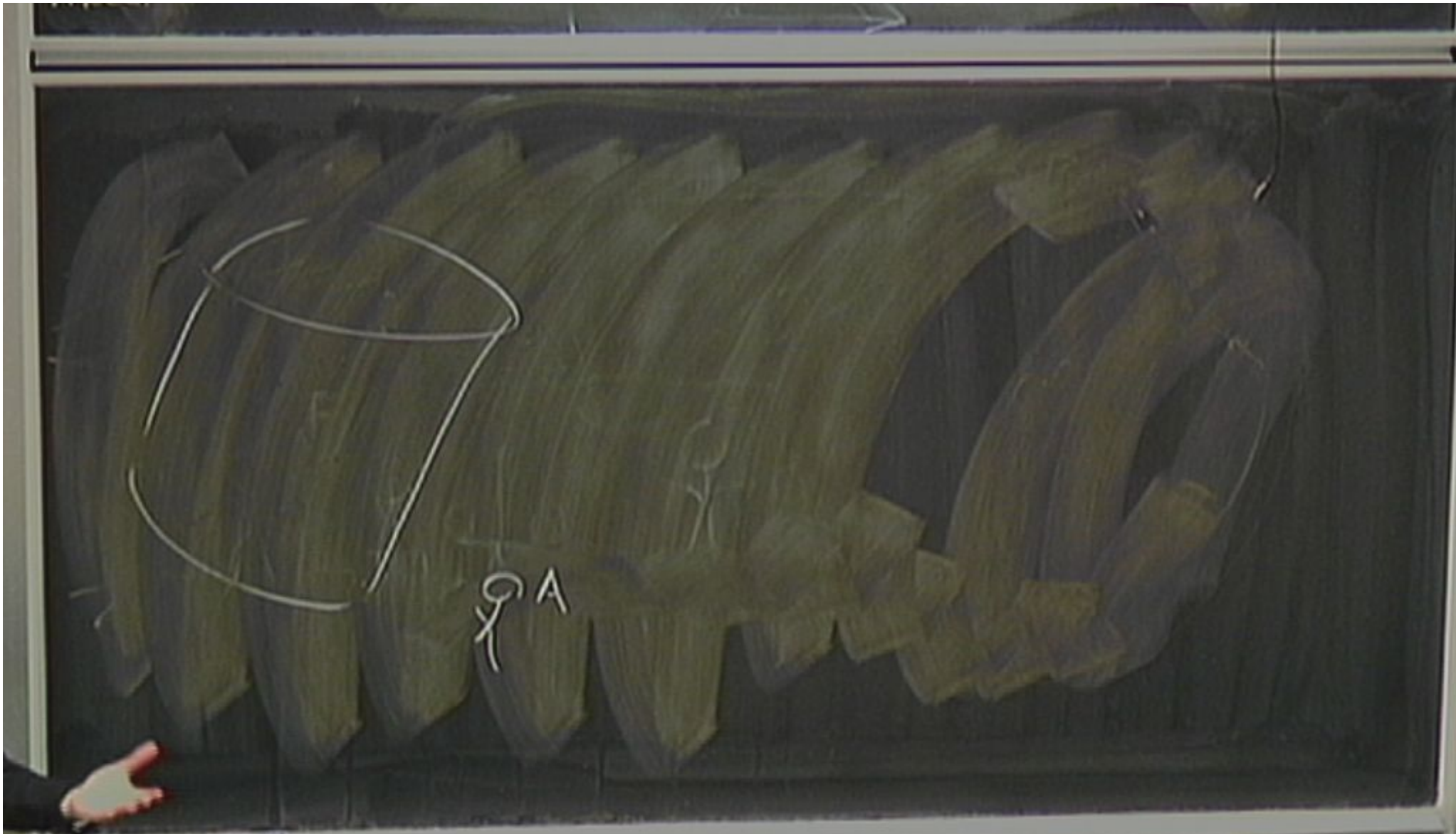


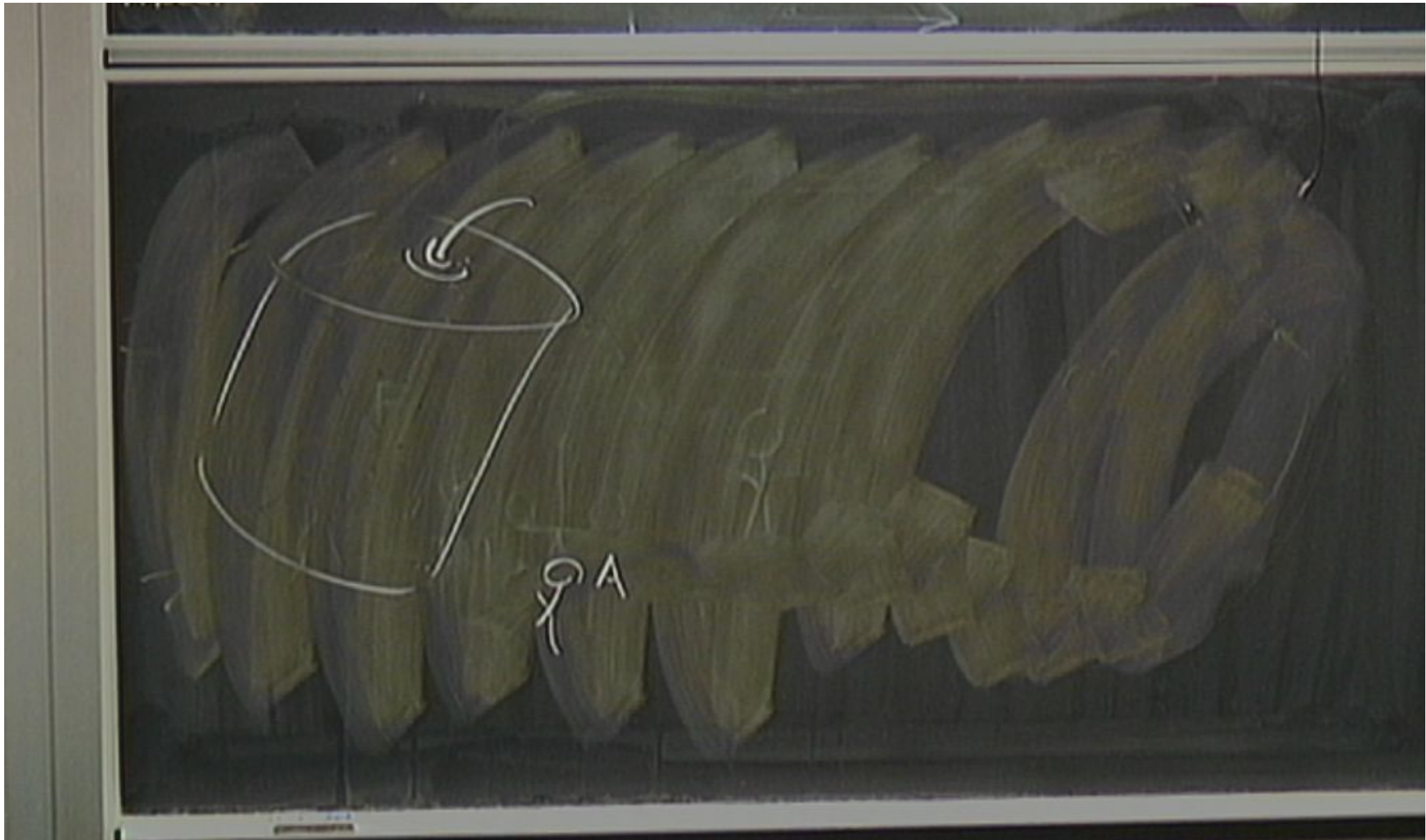
Length Contraction



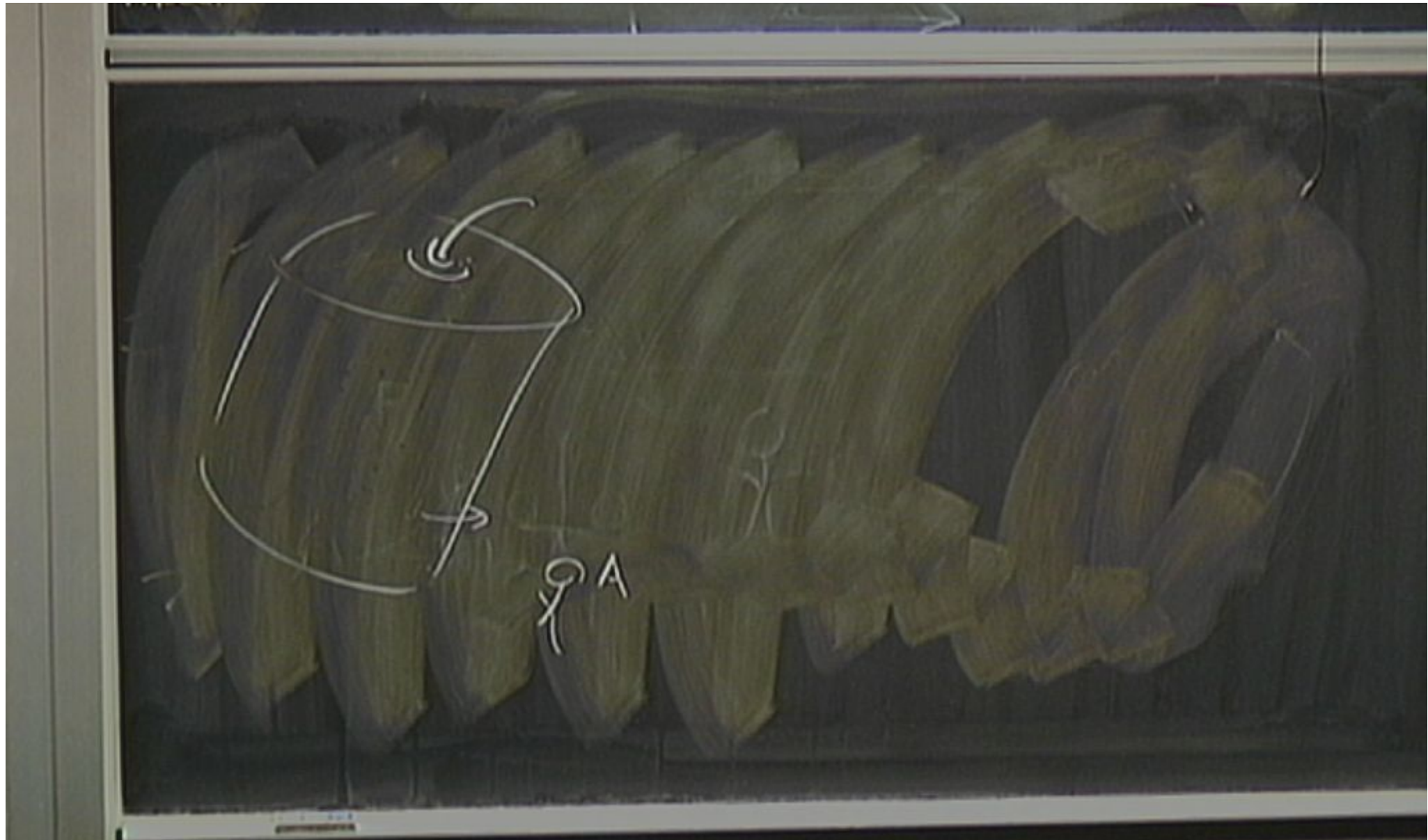
inside
circumference
(rotating)
greater







FAH
SOLUTION
SOLUTION



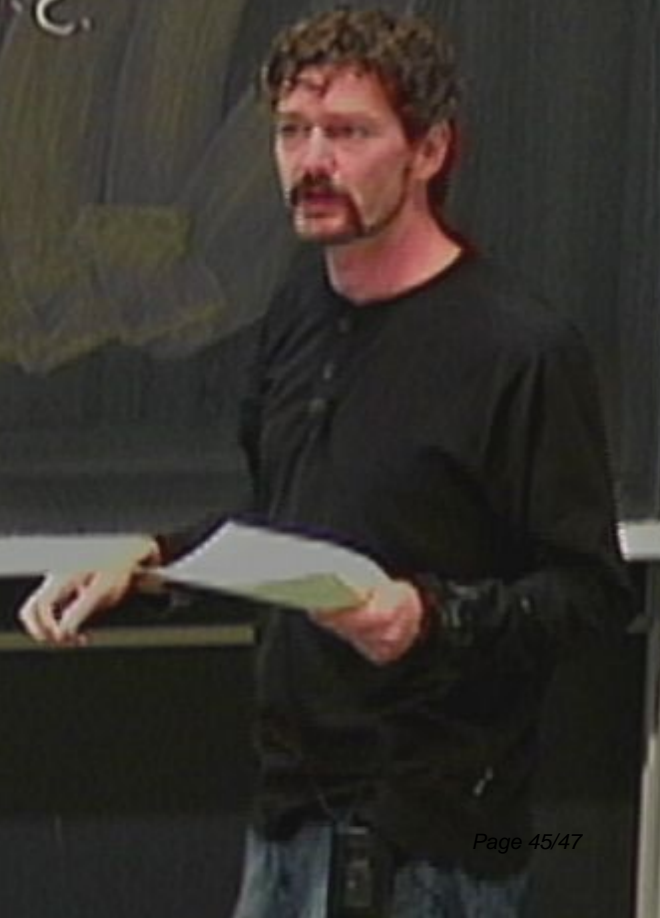
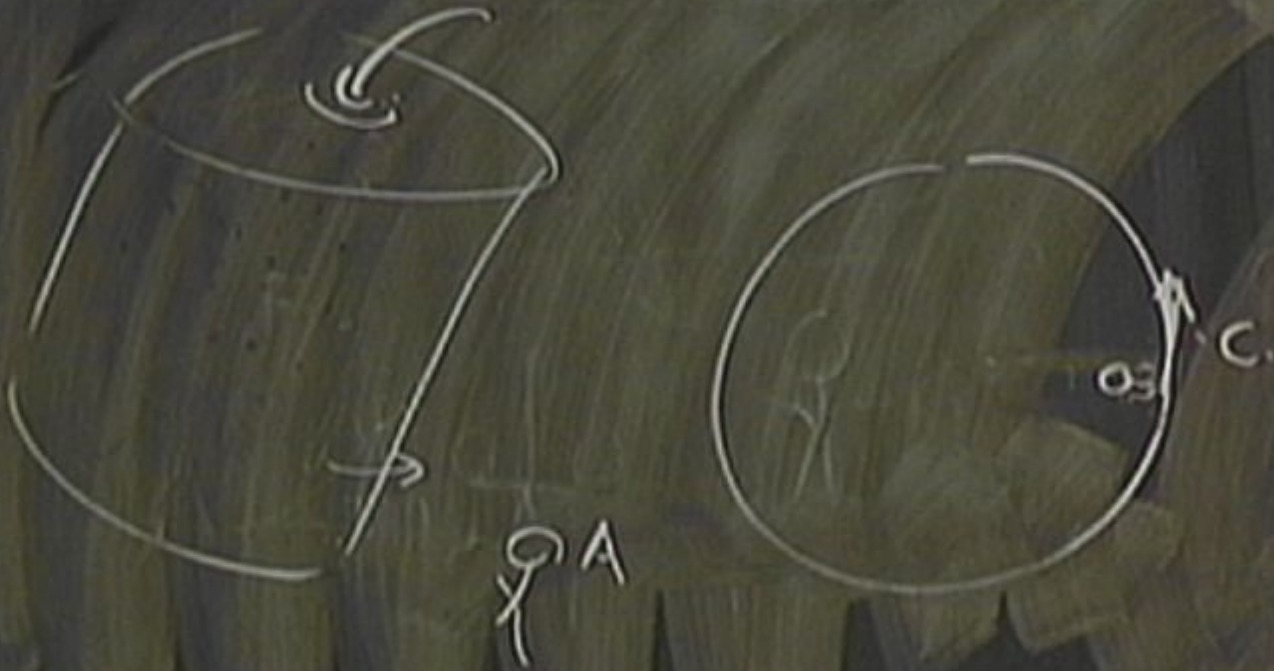
CAUTION
DO NOT TOUCH
THIS SURFACE



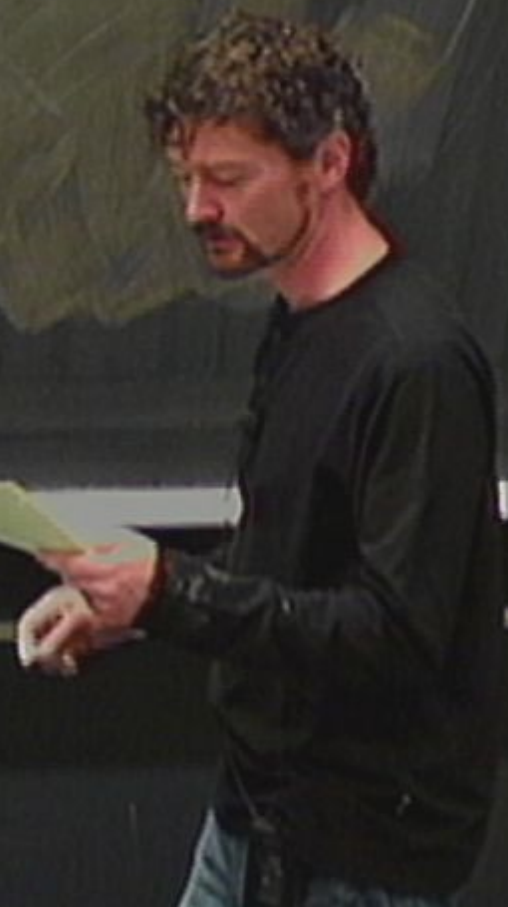
ρA



$L = \text{proper width of Bob.}$



$L = \text{proper width of Bob. (same Alice)}$
 $l = \text{moving " " "}$



L = proper width of Bob. (same Alice)

l = moving " " "

$$= \sqrt{1 - v^2/c^2} \cdot L$$

