GEH1027 **2020/21 S2**
Einstein's Universe and Quantum Weirdness **Tutorial 1**

1) Could you explain to a classmate how *The Relativity Principle* is related to Galileo's Law of Inertia and Newton's First Law?

2) Could you explain in your own words the 2 Postulates in Einstein's Special Relativity Theory? Which postulate was Einstein's real contribution?

3) What does the Lorentz factor suggest to us?
Could you describe Invariance and covariance to a classmate?

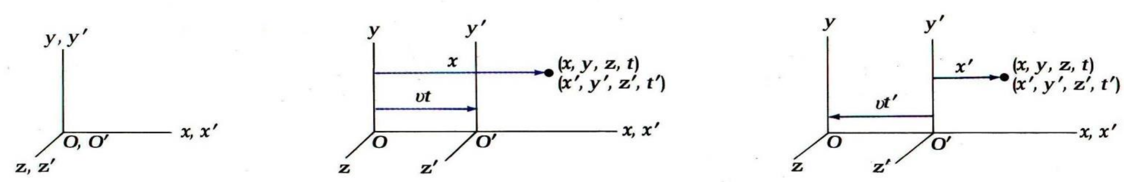
→ $100 \times \sqrt{1 - 0.99^2} = 14.1\,m$

4a) Alice is moving by you at 0.99c in a spaceship that is 100 meters long at rest. How long is it as it moves by you?
4b) Alice now is moving towards you at 0.9c. Your friend Jack jumps into his spaceship and, from your point of view, goes in Alice's direction at 0.8c.How fast will Alice see jack approaching?

$u = \frac{0.9c + 0.8c}{1 + (0.9 \times 0.8)} = 0.988 = 0.99c$ || Qn changed that both movg together

↳ $\frac{0.9 - 0.8}{1 + (0.9)(-0.8)} = 0.357$

5) Recall the peculiar velocity addition formula $u = \frac{v + u'}{1 + \frac{vu'}{c^2}}$ where u is the velocity observed by a person in the stationary inertial frame (co-ordinate system) and v is the velocity of the moving frame observed by the stationary inertial observer. See figure below. Suppose a ball is thrown out of the moving frame at a velocity of u', (like a ball thrown out of a uniformly moving bus). Note that c is the usual symbol for the speed of light.



(a) (b) (c)

Suppose we use "light" ball and it is moving in the same direction as the moving frame (to the right),
a) find u if $v = u' = c$ **b)** find u if $v = c$ **c)** find u if $u' = c$

Suppose we again use "light" ball and it is moving in different directions as the moving frame (either to the right or left)
d) find u if $v = c$ but $u' = -c$ **e)** find u if $v = -c$ **f)** find u if $u' = -c$

$u = \frac{c - c}{1 + \frac{c(-c)}{c^2}} = \frac{0}{0}$

Which scenario above has a mathematical inconsistent and why? (Tutor will assist)

$\therefore$ let $v = c - \Delta v$

$u = \frac{(c - \Delta v) - c}{1 + \frac{(c - \Delta v)c}{c^2}} = \frac{-\Delta v}{\Delta v / c}$

then let $\Delta v \to 0$

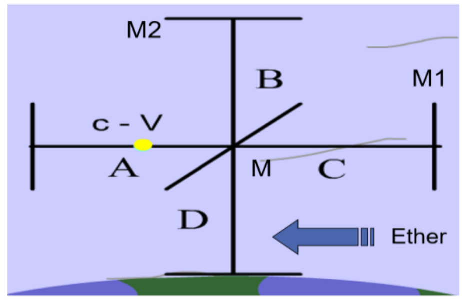
$\therefore u = -c$

6) Consider slide 58 and slide 59 (in Lecture 1),

About Michelson-Morley Experiment

Distance from M to mirror M1 = l_1

Consider light path from mirror M to mirror M1 and back to mirror M.
Call time taken by this light path t_A



$$t_A = \frac{l_1}{c-v} + \frac{l_1}{c+v} = \left(\frac{2l_1}{c}\right)\frac{1}{(1-(\frac{v}{c})^2}$$

Note : V = v
An ether wind blowing
in the direction M1to M

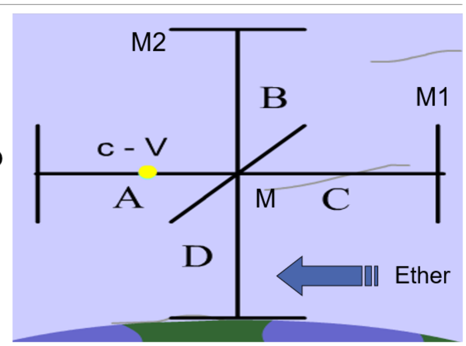
a) **Show that** $t_A = \frac{l_1}{c-v} + \frac{l_1}{c+v} = \left(\frac{2l_1}{c}\right)\frac{1}{(1-(\frac{v}{c})^2}$.

$$\frac{l_1(c+v)+l_1(c-v)}{c^2-v^2} = \frac{l_1(2c)}{c^2-v^2} = \frac{2l_1c}{c^2}\left(\frac{1}{1-(\frac{v}{c})^2}\right) = \frac{2l_1}{c}\left(\frac{1}{1-(\frac{v}{c})^2}\right)$$

About Michelson-Morley Experiment

Distance from M to mirror M2 = l_2

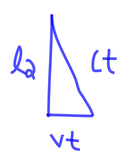
Consider light path from mirror M to mirror M2 and back to mirror M.
Call time taken by this light path t_B



$$t_B = \left(\frac{2l_2}{c}\right)\frac{1}{\sqrt{(1-(\frac{v}{c})^2}}$$

Note : V = v
An ether wind blowing
in the direction M1to M

b) Show that $t_B = \left(\frac{2l_2}{c}\right)\frac{1}{\sqrt{(1-(\frac{v}{c})^2}}$.



$$(ct)^2 = l_2^2 + (vt)^2$$

$$c^2t^2 = l_2^2 + v^2t^2$$

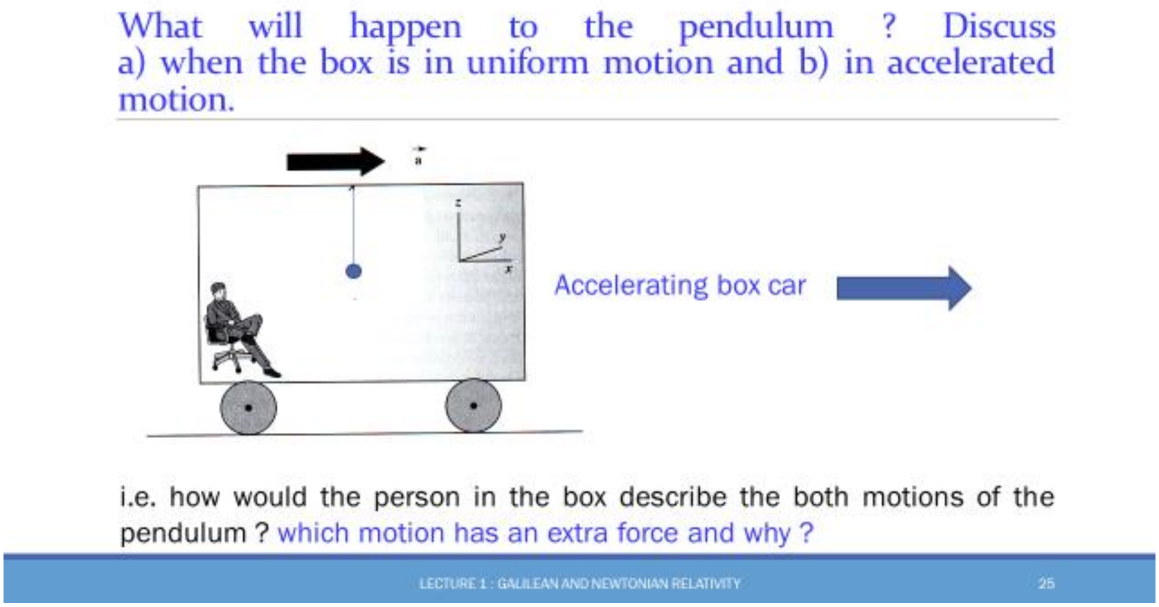
$$t^2 = \frac{l_2^2}{c^2-v^2} \rightarrow t = \sqrt{\frac{l_2^2}{c^2-v^2}}$$

$$2t = \frac{2l_2}{\sqrt{c^2-v^2}}$$

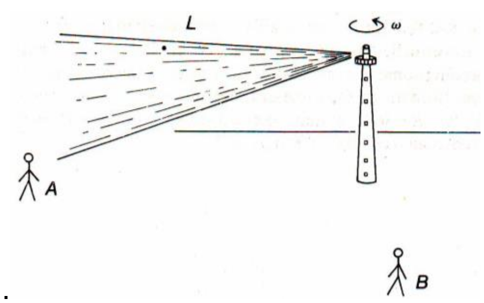
$$t_B = \frac{2l_2}{c}\left(\frac{1}{\sqrt{1-(\frac{v}{c})^2}}\right)$$

#

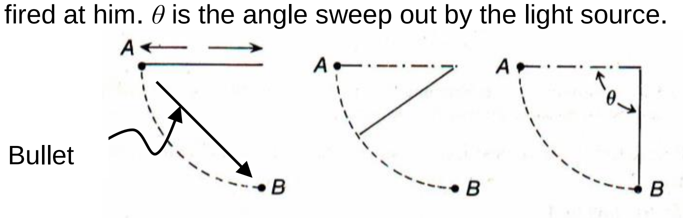
7) Consider the following slide (in Lecture 1),



8) Consider a powerful light rotating like a lighthouse given below. Observer *A* and *B* are watching the sweep of light some distance away *L* from the rotating light source with angular speed ω.



When *A* sees the search light, he fired a bullet at *B* and when *B* sees the search light, *B* ducks because *A* has fired at him. θ is the angle sweep out by the light source.



Discussion:

Does this not mean that a warning has gone from *A* to *B* with a speed faster than *c*?

As long as omega can turn at a rate faster than the bullet can travel, then no issue