

Relativity Journal

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1 Lecture One

Newtonian Relativity

- World time, same rate(ricking) different unit, different zeros.
- Absolute space
- Galilean Transformation: if we want to transform between two different coordinates, one moving with the speed v_x

$$\begin{cases} (t, x, y, z) \\ (t', x', y', z') \end{cases} \quad (1)$$

and the relation would be:

$$x' = x - v_x t \quad (2)$$

with z' and y' being equal to z and y respectively. from the equation we can see that the acceleration is seen equally in both systems.

- $\mathbf{F} = m\mathbf{a}$ would be invariant in both systems (under galilean transf.), meaning both force and mass is invariant(acceleration was invariant by eq1).
- axiom of mass in newtons prespective: type 1 the thing that appears in $f = ma$ against the movement, innersi. It's is completely apart from the gravitation m_I . type 2 the thing that is described by the gravitation force on an object m_{gr} . **mass**: active mass: creator of the gravitational field. (field producer) / passive mass: acted on with the gravitational field. (test particle).
- for example a pendulum with innertial mass m_I would be governed by $F = -kx = m \frac{d^2 x}{dt^2}$ having:

Callout — Weak Equivalence Principle

$$F = m_I a = -kx$$

$$= m_I \frac{d^2 x}{dt^2} + kx = 0$$

$$= \frac{d^2 x}{dt^2} + \frac{k}{m_I} x = 0$$

$$= \frac{d^2 x}{dt^2} + \omega^2 x = 0$$

$$F = -m_g g \sin \theta$$

$$= m_g g (\theta \ell) / \ell$$

$$= (-m_g g / \ell) x \Rightarrow k = m_g g / \ell$$

- Mach on Absolute space: why ballging happens or a bucket of water rotating changes shape (the water), newton says it is because water understands it's rotating with respect to the absolute space. But mach says it's because it's relation with other things in the world. [to be read about mach opinions.]

Excercise — Is Maxwell's equations invariant with respect to galilean transformations?

2 Lecture Two

Special relativity

- There are two principles in special relativity.
 - RP \equiv relativity principle, which means that all inertial frames are equal. Physical laws won't change
 - Constant and an invariant velocity: there is a maximum speed in nature that information can surpass. This speed is the speed of light.
- these principles would have results such as:
 - length contraction
 - Time dilation
 - Relativity simultaneity

Callout — We are having a flat space time in SR. and the Physics would have to be the same. This means that we are mostly experimenting in the domain of special relativity, and since we are going beyond the newtonian relativity. We are expecting any theory that we make to be lorentz invariant (works with special relativity).

- The fact that we have equivalence between inertial frames, means that we can calculate our laws of physics in any of them! This helps in simplifying different phenomenas.
- **An example:** A man on a belt moving up on an incline would calculate the work $(mg)v\sin\theta$ but a stationary person would calculate $(mgsin\theta)v$ which is the same.
- Now assume a train moving with velocity v . A man at the middle of the wagon turns up a light. From his point of view the light reaches both ends at the same time,, say 3 o'clock then an observer outside the train would see that the light reaches at different instances