Relativity
Journal

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Contents

1 Lecture One

Newtonian Relativity

- World time, same rate(ricking) different unit, different zeros.

- Absolute space

- Galilean Transformation: if we want to transoform between two different coordinates, one moving with the speed v_x

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

and the relation would be:

$$x' = x - v_x t \tag{2}$$

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

- **F= ma** 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 $F = -kx = m\frac{d^2x}{dt^2}$ having:

> Callout — Weak Equivalence Principle

$$\begin{aligned}
F &= m_I a = -kx \\
&= m_I \frac{d^2x}{dt^2} + kx = 0 \\
&= \frac{d^2x}{dt^2} + \frac{k}{m_I} x = 0 \\
&= \frac{d^2x}{dt^2} + \omega^2 x = 0 \\
F &= -m_g g \sin\theta \\
&= m_g g(\theta\ell)/\ell \\
&= (-m_g g/\ell)x \Rightarrow k = m_g g/\ell
\end{aligned}$$

- 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 ≡ 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).

- TThe 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 $(mg\sin\theta)v$ 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 lighht 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.[Thought Experiment by Einstein.]

3 Lecture Three: K-Calculus

[Check out the book and the pictures of the board from the lecture since we missed the first 15min or so.]

- **Photon in medium:** assuming two observers one haveing a bucket of water assuming that a light is passing through the bucket (in the water) we want to calculate the speed of light from the prespective of the other observer A, (observer B has velocity v with respect to A):
  The speed of the signal in bucket with respect to B is $u' = v_{BC}$:

  $$\begin{aligned} u &= \frac{v+u'}{1+\frac{vu'}{c^2}} \\ &\approx (v+u')(1-vu'/c^2) \\ &= v+u'(1-vu'/c^2) \\ &= u'+v(1-u'/c^2) \\ &= u'+v\kappa = u'+v(1-\frac{1}{n^2}) \end{aligned}$$

  Where n is the diffraction constant [zarib shekast]. Thus comparing with galilei transformations:

  $$\text{Galilei:} \quad u = u' + v \tag{3}$$
  $$\text{New transf.:} \quad u = u' + \kappa v \to \kappa < 1 \tag{4}$$

  There's a constraint causing the light spped to look the same in every observers prespective.

- **Simultaneity in Relativity:** Back to the example of train, two events happen each at one of the ends of the train causing light emittion. leading us to write [attention to the board picture:]

  $$\begin{cases} x_P = \frac{t_w - t_s}{2} \\ x_Q = \frac{t_u - t_r}{2} \end{cases} \Rightarrow x_P = x_Q$$

  from the prespective of B

  $$\begin{cases} t_P = \frac{1}{2}(t_s + t_w) & t_s > t_R \\ t_Q = \frac{1}{2}(t_R + t_u) & t_w > t_u \end{cases} \Rightarrow t_P > t_Q$$