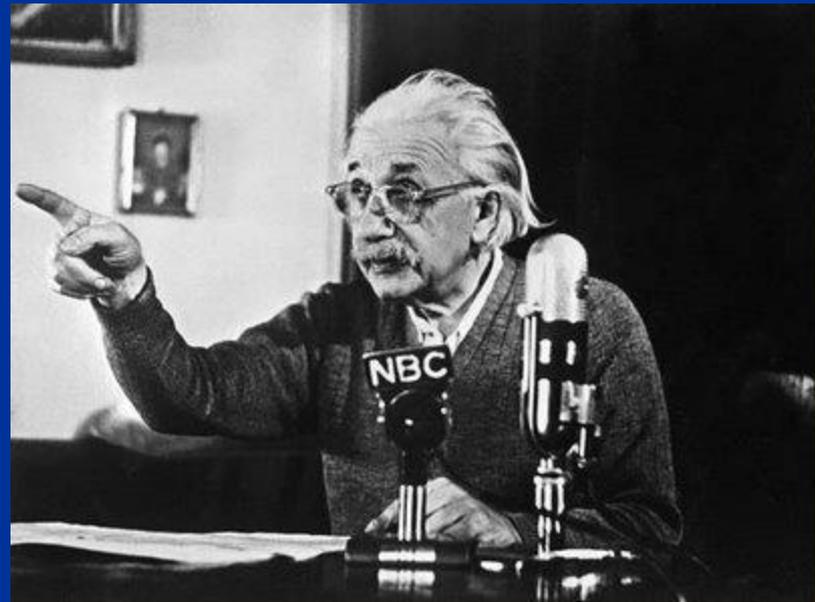# Special Theory of **Relativity**
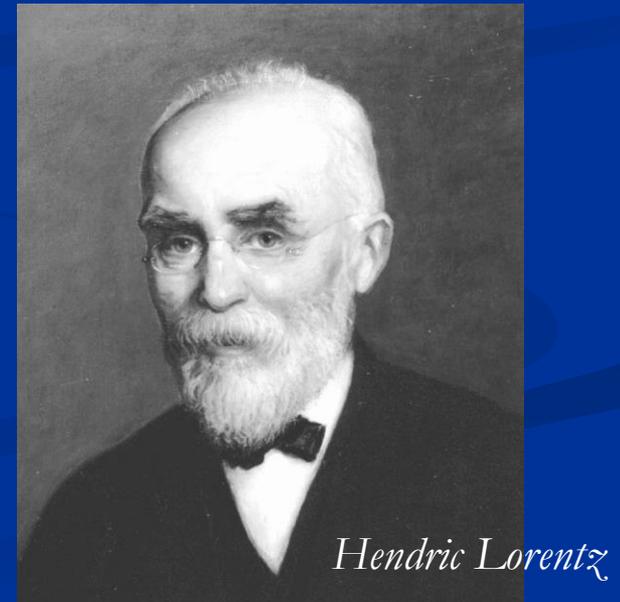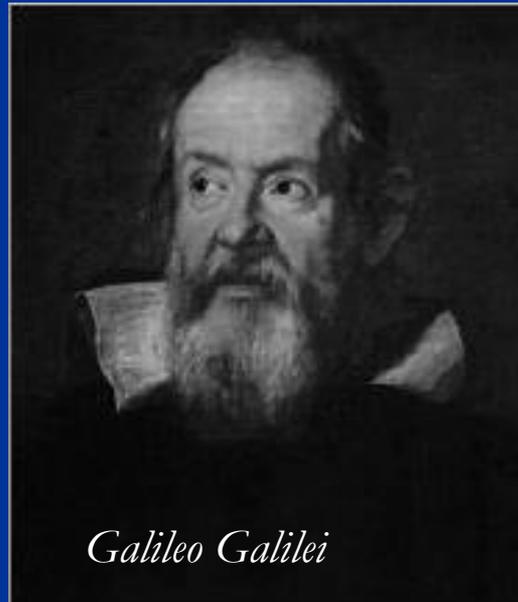

10th Lecture

Transformations Equation

Transformation equations are used to transform between the coordinates of two reference frames. There are two types of transformation equations.

1. Galilean Transformation Equation (without relativistic effect!)

2. Lorentz Transformation Equation (with relativistic effect!)

Galileo Galilei

Hendric Lorentz

Four Vectors / Four Cdts Systems
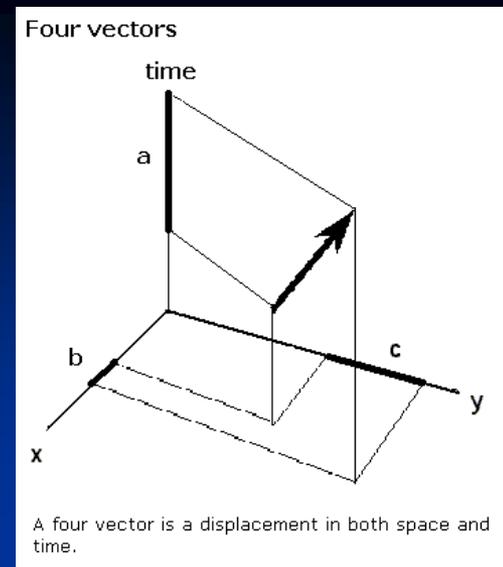
In the theory of relativity, a four-vector is a vector in a four-dimensional real vector space, called Minkowski Space. It differs from a vector in that it can be transformed by Lorentz Transformation. The usage of the four-vector name tacitly assumes that its components refer to a standard basis. The components transform between these bases as the space and time coordinates differences, $(\Delta x, \Delta y, \Delta z, \Delta t)$ under spatial translations, rotations and boosts [a change by a constant velocity to another inertial reference frame]

Minkowski Four-Dimensional Space ("World")

We can characterize the Lorentz Transformation still more simply if we introduce the imaginary *Sqrt[-1] = i* *ct* in place of t, as time variable. If in accordance with this, we insert,

$$x_1 = x$$

$$x_2 = y$$

$$x_3 = z$$

$$x_4 = i\,c\,t$$

Where, $i = \sqrt{-1}$

and similarly for the accented system K', then the condition which is identically satisfied by the transformation can be expressed, thus;

$$x_1^2 + x_2^2 + x_3^2 + x_4^2 = x_1'^2 + x_2'^2 + x_3'^2 + x_4'^2$$

That is, by the afore-mentioned choice of "co-ordinates" is transformation into this equation.

Minkowski Four-Dimensional Space ("World")

We see from the above equation that the imaginary time co-ordinate $X4$ enters into the condition of transformation in exactly the same way as the space co-ordinates $X1$, $X2$ and $X3$. It is due to this fact that, according to the theory of relativity, the " time " $X4$ enters into natural laws in the same form as the space co-ordinates $X1$, $X2$ and $X3$.
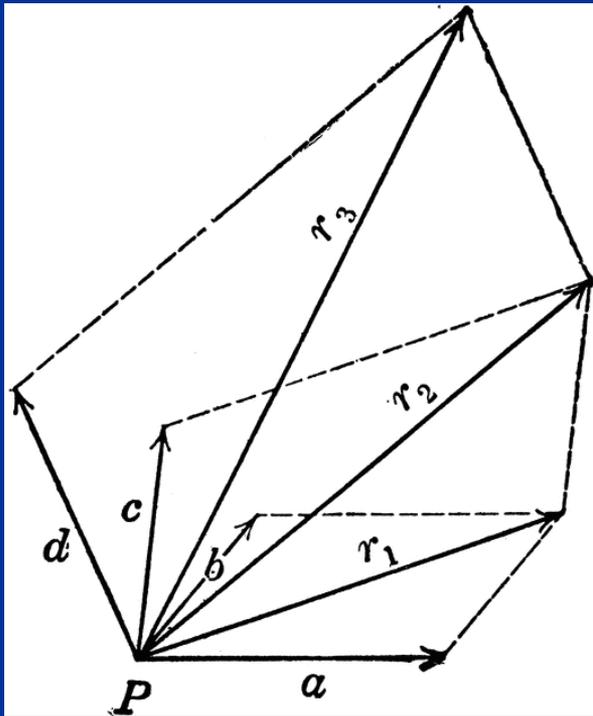
A four-dimensional continuum described by the co-ordinates $X1$, $X2$ and $X3$ was called "**World**" by Minkowski, who also termed a point-event a "World-point". From a "happening" in three-dimensional space, Physics becomes, as it were, an "existence" in the four-dimensional "World".

Causality

Causality is the relationship between an event (the cause) and a second event (the effect), where the second is a consequence of the first.

Theories of causality in Indian Philosophy focus mainly on the relationship between cause and effect. The various philosophical schools (*darsanas*) provide different theories.

Causality in Eastern Philosophy

According to Lard Buddha's philosophy of causality, " **There is a cause for every effect and the cause precedes the effect !** "

$$t_{effect} - t_{cause} > 0_{always}$$

But the other religions belive….
The God is the **ultimate creator and sustainer of the universe**, responsible for all existence, from the cosmos and nature to humanity, often seen as the source of purpose and good, even amidst suffering, with scriptures emphasizing His power to work all things for good and provide for believers

Summary :
You can plan but god decide

BUT

How do you explain "Child's Death" ???

How do you explain "Child's (foetus) Abortion" ???

Rebirth

Reincarnation + Karma

Causality in Eastern Philosophy

How do you explain "Child's Death" ???

How do you explain "Child's (fetus) Abortion" ???

Rebirth

Reincarnation

+

Karma

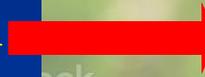**A new or second birth.** The rebirth of the soul.

eg:

Caterpillar → butterfly

Causality in Eastern Philosophy


← Rebirth

Reincarnation →

+

Karma

eg: Caterpillar → butterfly

A new or second birth. The rebirth of the soul.

Buddhists believe that **when someone dies, they will be reborn again as something else**. What they are reborn as depends on their actions in their previous life (karma). The cycle of rebirth is called samsara and it is an ongoing cycle of life, death and rebirth.

Causality in Western Philosophy

According to the Newton's third law, " **every action has a reaction equal in magnitude and opposite in direction** "
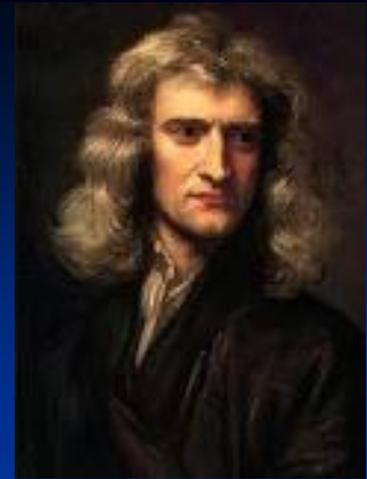
Whenever a particle A exerts a force on another particle B, B simultaneously exerts a force on A with the same magnitude in the opposite direction. The strong form of the law further postulates that these two forces act along the same line. Newton's third law is sometimes referred to as the **action-reaction law**.

Action → Cause

Reaction → Effect

$$t_{effect} - t_{cause} > 0_{always}$$

Causality

How the Special Theory of Relativity was strengthened by the concept of causality ???

If we consider some effect due to some cause in frame S,

For cause in frame S, $(x_1, \ y_1, \ z_1, \ t_1)$

For effect in frame S, $(x_2, \ y_2, \ z_2, \ t_2)$ where, $t_2 > t_1$

If we consider some effect due to some cause in frame S',

For cause in frame S', $\left(x_1^1, \ y_1^1, \ z_1^1, \ t_1^1\right)$

For effect in frame S', $\left(x_2^1, \ y_2^1, \ z_2^1, \ t_2^1\right)$ where, $t_2^1 > t_1^1$

Using the Lorentz Transformation Equation,

$$t^1 = \gamma\left(t - \frac{v}{c^2}x\right)$$ where, $\gamma = \dfrac{1}{\sqrt{1 - v^2/c^2}}$

How the Special Theory of Relativity was strengthened by the concept of causality ???

For cause ; $t_1^1 = \gamma\left(t_1 - \frac{v}{c^2}x_1\right)$

For effect ; $t_2^1 = \gamma\left(t_2 - \frac{v}{c^2}x_2\right)$

Then, $t_2^1 - t_1^1 = \gamma\left(t_2 - \frac{v}{c^2}x_2\right) - \gamma\left(t_1 - \frac{v}{c^2}x_1\right)$

$t_2^1 - t_1^1 = \gamma\left([t_2 - t_1] - \frac{v}{c^2}[x_2 - x_1]\right)$

$\Delta t^1 = \gamma\left(\Delta t - \frac{v}{c^2}\Delta x\right)$

$\Delta t^1 = \gamma\,\Delta t\left(1 - \frac{v}{c^2}\frac{\Delta x}{\Delta t}\right)$

How the Special Theory of Relativity was strengthened by the concept of causality ???

➡️ $$\Delta t^1 = \gamma\, \Delta t \left(1 - \frac{v}{c^2} \frac{\Delta x}{\Delta t} \right)$$ ➡️ $$\Delta t^1 = \gamma\, \Delta t \left(1 - \frac{vu}{c^2} \right)$$

If $\Delta t^1 < 0$ ➡️ $1 < \dfrac{uv}{c^2}$ because $\Delta t^1 < 0$ & $\Delta t > 0$

∴ $c^2 < uv$ ∴ $c < u$

Because relative velocity of the two frames S & S', v < c

In causality, $\Delta t^1 < 0$ is not correct!
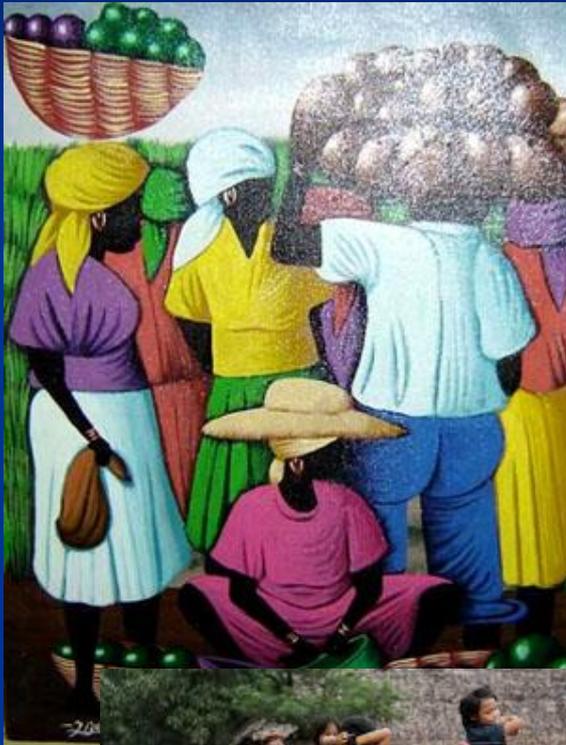
According to the causality, $\Delta t > 0$ and $\Delta t^1 > 0$,

➡️ $1 > \dfrac{uv}{c^2}$ that means $c^2 > uv$

∴ $c > u$ because $c > v$

This result supports to the Einstein's Special Theory of Relativity !

Special Theory of Relativity

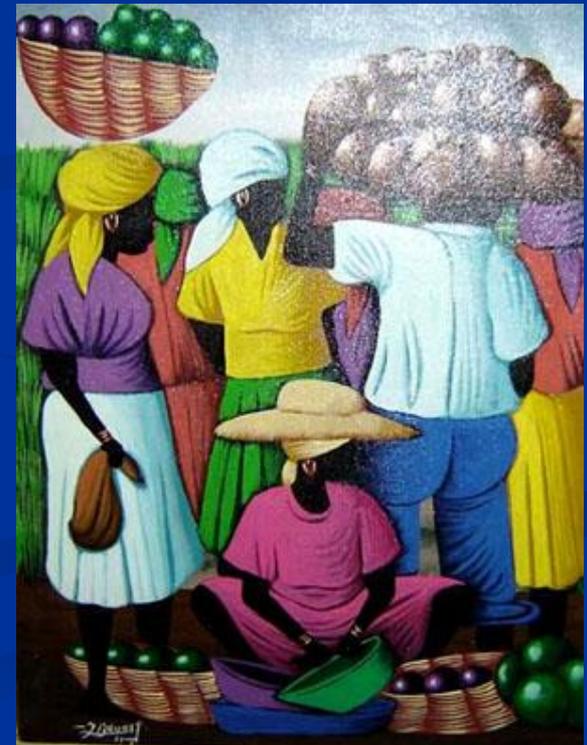For day to day life

Special Theory of Relativity For day to day life

Love

Society

Special Theory of Relativity For day to day life

Women

Men

Special Theory of Relativity For day to day life

Marriage

Politics

Special Theory of Relativity For day to day life

Concepts

Views

Special Theory of Relativity For day to day life

. . . .

Thank You !