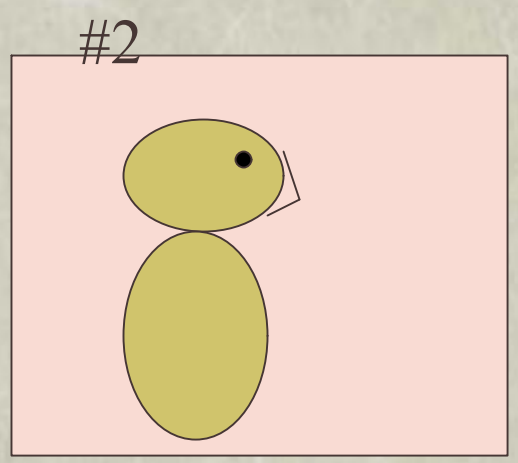
Chapter 12 Relativity

Physics 2001

Prof. Merry

Relativity

- Theory developed by Einstein connecting measurements of space, time, and motion made by one observer to those made by another observer in a different environment.

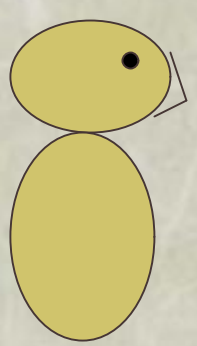


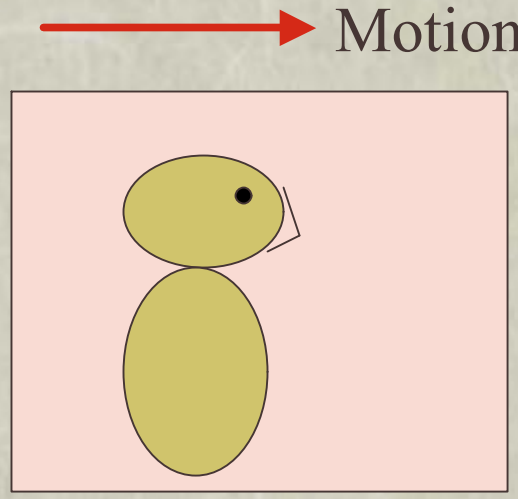
General Theory

- The general theory of relativity relates observations made in strong gravitational fields to those found in weak fields
- Not studied in this course

Special Theory

- The special theory of relativity relates experimental results for two observers moving at high speed with respect to one another





Two postulates of the special theory of relativity.

- The speed of light, c = 300,000 km/s ($3x10^8$ m/s), is the same for all observers, regardless of their motion.
- The laws of physics are the same for all observers moving uniformly, that is at constant velocity.

Relativistic Time Dilation

- Time dilation: $t' = t/(1-v^2/c^2)^{1/2}$
- for particle moving towards us with a velocity v. Time appears to us slower..
- Allows muons created by cosmic rays high in the atmosphere to get all the way to the ground before decaying

Relativistic Length contraction

- **L = L’ x (1-v2/c2)½**
- Length of very fast moving objects becomes shorter in direction of motion.
- If motion is perpendicular to the dimension there is no change..

Length Contraction Graphic

- **http://www.walter-fendt.de/ph11e/timedilation.htm**

Spaceship Moving at the
10 % the Speed of Light

99 % the
Speed of Light

Length Contraction Link

- http://www.walter-fendt.de/ph11e/timedilation.htm

Rest Mass Energy

- Einstein's **rest energy equation**
- $E_0 = mc^2$
- **Energy associated with a mass m, = m x square of speed of light, C x C**
- **E.g. m = 5 kg, E = 5 x3 x 10^8 x 3 x 10^8**
- **=*45 x* 10^{16} Joules**

Four Types of Forces

- **Gravitational force** The attractive force that acts between all pairs of objects.
- **Strong nuclear force** It is the force that holds neutrons and protons together in the nucleus.
- **Weak nuclear force** It is responsible for beta decay
- **Electromagnetic force** The force that acts between charged particles. Can be attractive or repulsive.

Elementary Particles

- **Elementary particles** The basic, indivisible building blocks of the universe. The fundamental constituents from which all matter, antimatter, and their interactions derive. They are believed to be true "point" particles, devoid of internal structure or measurable size.

Antimatter

- **Antiparticle** A charge-reversed version of an ordinary particle. A particle of the same mass (and spin) but of opposite electric charge.

Interaction of Particles

- Some particles are emitted from the nucleus of certain unstable atoms
- These particles can be matter (electrons, protons, …) or energy (X Rays and Gamma Rays)

Medical Use of Emission

- Many Medical Tools Use this process
- X Rays
- PET (Uses Positrons and Emitted Gammas)
- NMR (Nuclear Magnetic Resonance)
- Radiation Therapy

Positron Emission Tomography or PET

- **The most advanced medical diagnostic imaging technology available today for the early and accurate detection of cancer and its recurrence.**
- **also provides valuable information regarding certain diseases of the heart (e.g., determination of tissue viability) and brain (e.g., dementia, Parkinson's disease).**

Solving $(1- v^2/c^2)^{1/2}$

- **Formulas:** $(1- v^2/c^2)^{1/2}$ **used quite frequently**
- **We have to square v and c and divide very big numbers.**
- **To make the math easy v is given in terms of c, e.g. v = .9 c. This makes things easy.**
- **Because then v/c = .9c/c or .9 Since** $v^2/c^2 = (v/c)^2$
- $v/c = .9$ $v^2/c^2 = .9 \times .9 = .81$
- **and** $1 - v^2/c^2 = 1-.81 = .19$ **Then take sq.rt. of .19=.43**
- **Procedure take v/c, square it, subtract from 1 then take the square root of the result.**

Scientific Notation

- Power of 10 and number between 1 and 10
- 3.3×10^6
- If you have 33×10^5 as your answer you must convert 33 to 3.3×10 then add 1 to the power of 10, and you get 3.3×10^6

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