Topic 7 - Background

8. The speed of light is a constant for all observers, regardless of the speed of the observer.

1905 – Einstein + the theory of special relativity

* no such thing as absolute rest so it impossible to distinguish between moving reference frames.
* the speed of light is always the same regardless of the speed of the observer
  ↳ an observer would measure the speed of light to $3.0 \times 10^8 ms^{-1}$ regardless of whether they were stationary relative to the source, moving towards the source or moving away from the source.

5 consequences
- the time interval between two events depends on the speed of the observer.
- the length of a moving object depends on the speed of the observer.
- the mass of a moving object depends on the speed of the observer
- it is impossible for anything (except light) to travel at the speed of light (or something with zero rest mass)
- mass and energy are equivalent.

significant for TOPIC 7.

9. Mass + Energy are equivalent

Mass + energy are different manifestations of the same thing measured in different units. (kg + J)

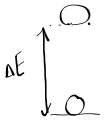
They are related by the equation:

$E = mc^2$ $(c = 3.0 \times 10^8 \text{ m/s})$

Energy equivalent of its mass

Consider an object placed on a table that has more potential energy

The object has more mass.



$E = mc^2$

$\Delta E = E_2 - E_1$

$\Delta E = m_2c^2 - m_1c^2$

$\Delta E = c^2(\Delta m)$

$\Delta m = \frac{\Delta E}{c^2}$

$\Delta m = \frac{1\text{ J}}{(3.0 \times 10^8 \text{ ms}^{-1})^2}$

$\Delta m = 1.1 \times 10^{-17}$ kg

This mass is insignificant when dealing with everyday objects.

This mass difference is HUGE when working at the nuclear scale.

Rest mass → the mass that an object has when it is at rest relative to the observer.

relativistic mass → the mass that an object has when it is in motion relative to the observer.

Example

The rest mass of an electron is 9.1×10^{-31} kg. What is the energy equivalent of this mass?

Answer in J and MeV.

$1\text{eV} = 1.6 \times 10^{-19}\text{ J}$

$E = mc^2$

$E = (9.1 \times 10^{-31}\text{ kg})(3.0 \times 10^8 \text{ ms}^{-1})^2$

$E = 8.2 \times 10^{-14}\text{ J}$

$E = 5.1 \times 10^5 \text{ eV}$

$E = 0.51$ MeV

10. It is impossible for any body with a non-zero rest mass to travel at the speed of light.