What is mass

We do not actually know what mass is!

The everyday concept of mass is that defined by trading standards officers who check scales against a set of standard masses. Physicists and Chemists have traditionally used the beam balance to measure mass. We will call the mass of an object as measured with a beam balance its *physical mass*.

Newton described three properties of matter which he attributed to mass; the property of inertia; the ability to create the attractive force of gravity and the ability to be attracted by gravity. Einstein gave mass another property, that of being equivalent to energy. Most scientists seem to think of mass and charge as two ingredients of elementary particles and in this sense, their concept of mass is in the same class as the classification of the four basic elements of earth, water air and fire. The deeper one delves into modern physics, the more mysterious this "element" becomes.

We are of the opinion that nature has one basic element: energy which has two stable forms; electric flux which terminates in charge and magnetic flux which always forms continuous loops. That the whole basis for the structure of matter is that moving electric flux (*D*) generates magnetic intensity (*H*) and moving magnetic flux (*B*) generates electric intensity (*E*) with the result that all actions of nature involve the transfer of energy between electric and magnetic fields. Electrons (and quarks) possess the property we call inertial mass because the motion of their electric field (through the background of all the other electric fields of elementary charged particles) generates a magnetic field which contains their kinetic energy. Mathematical analysis of this process shows that inertial mass is proportional to the energy content of the electron's electric field. Inertial mass is therefore a property of the electric nature of matter.

Newton's original conclusion was that inertial mass, *active gravitational mass* and *passive gravitational mass* are the same thing. In fact, they are proportional to one another and are made equal by the way in which we define our units. When it was discovered that beta radiation consisted of electrons moving at near light speed, experiments to measure charge and mass showed that inertial mass was an over simplistic concept because the mass seemed to depend on the direction of the acceleration with a greater increase for linear acceleration than for centripetal acceleration.

Lorentz showed that the laws of Electricity and Magnetism predicted a feedback effect in which the motion of the electron's magnetic field generated an electric *E* field which affected the electron's electric *D* field causing a contraction in length and affecting inertial mass. He introduced the terms *transverse mass* resisting centripetal acceleration and *longitudinal mass* resisting linear acceleration. In latter years, these terms were dropped and replaced by the term *relativistic mass*.

In adopting the concept of *relativistic mass*, we recognise that in centripetal acceleration the speed of the particle remains constant while in linear acceleration, the speed changes. The relativistic mass $m_r = \gamma m$ where γ is a function of velocity $\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1}$. The accelerating force also has to do work to increase the relativistic mass. When this is taken into account, the net force and acceleration give the relativistic mass. We have shown that Newton's second law may be written as:

$$\vec{F} = \gamma \begin{pmatrix} \gamma^2 a_x \\ a_y \\ a_z \end{pmatrix} m$$

where a_x, a_y and a_z are the components of the acceleration in co-ordinates such that the velocity lies in the x axis.

It must be emphasised that all of these different properties relate to the nature of the electron (and quarks) as an entity consisting of an electric field and the terminal charge on its inner surface. They are all related to its energy content. They arise from the different ways in which we measure mass.

- m_p Physical mass is measured with a beam balance against a standard mass
- m_i Inertial mass is measured from force and acceleration
- m_l Longitudinal mass is measured from electric force on a charge and its linear acceleration
- m_t Transverse mass is measured from the magnetic force on a moving charge and the resulting centripetal acceleration
- m_r Relativistic mass: replaces m_l and m_t being equal to m_t
- m_{pg} Passive gravitational mass is inferred from acceleration under gravity
- m_{ag} Active gravitational mass is assumed defining a gravitational constant which is then measured by the attraction between spheres of know physical mass.
- m_e Einstein Mass as in $E = m c^2$

It is convenient to define the units of mass in such a way that *active gravitational mass* and *passive gravitational mass* are both equal to the *physical mass*. This is accomplished by introducing the gravitational constant G.

We shall show that:

$$m_e = m_{pg} = m_{ag} = m_r e^{\frac{\Phi}{c^2}}$$

$$m_r = \gamma m_p$$

$$m_i = m_r e^{-3\frac{\Phi}{c^2}} = \gamma m_p e^{-3\frac{\Phi}{c^2}}$$

The two gravitational masses are equal. There are two separate factors; the effect of gravitational potential and the effect of velocity. The relativistic increase in mass contributes to the gravitational mass, but the gravitational mass is reduced by gravitational potential. Newton's inertial mass is modified by velocity and gravitational potential, the latter resulting in a factor of $e^{-3\frac{\Phi}{c^2}}$.