1) Methodology:

According to Einstein's equivalence principle gravity cannot be detected at a point. This means energy momentum is fundamentally non-local and hence non-tensorial.After Einstein's original work on energy-momentum formulations (Trantman 1958),different prescriptions for pseudo-tensors were given by Papapetrou 1951, Bergmann-Thomson 1953, Mϕller 1958, Weinberg 1972, Landau-Lifshitz [1-9].These energy-momentum complexes were local objects while it was believed that the suitable energy-momentum of the gravitational field was only total. Taking the assumption that we need to have Einstein's equation at the end, different prescriptions were given by researchers. In 2000, Sousa and Maluf [10],[11] established the Hamiltonian of arbitrary teleparallel theories and showed that the TEGR is the only viable teleparallel gravity theory. In a teleparallel gravity, space-time is represented by Weizenböck [12] manifold of distant parallelism. As a gauge theory of translational group, the fundamental field of teleparallel gravity is the gauge potential $\Lambda^{(a)}{}_{\mu}$ where the space-time indices are the Greek alphabets μ,ν,σ,λ....... and the global SO(3,1) indices are the Latin alphabets (a),(b),(c),(d).....=(0),(1),(2),(3). The tetrad field $e^{(a)}{}_{\mu}$ s related to gauge potential by equation

$$e_{(a)}{}^{\mu}=\partial_{\mu} x^{(a)} + \Lambda^{(a)}{}_{\mu}$$

Choosing the line element for the space-times of the specific configuration we obtain the tetrad components and its inverse. The tangent space-indices are raised and lowered with the Minkowski metric co-efficients $\eta_{(a)(b)}$whereas the Riemannian space-time metric $g_{\mu\nu}$ is used to raise or lower the space-time indices μ,ν,......

Thus

$$g_{\mu\nu} = \eta_{(a)(b)}\, e^{(a)}{}_{\mu} e^{(b)}{}_{\nu}$$

Torsion reads

$$T^{\sigma}{}_{\mu\nu} = \Gamma^{\sigma}{}_{\nu\mu} - \Gamma^{\sigma}{}_{\mu\nu}$$

where the tetrad gives rise to WeitzenbÖck connection presenting a non-vanishing torsion but vanishing curvature

$$e_{(a)}{}^{\rho}\, \partial_{\mu} e^{(a)}{}_{\nu} = \Gamma^{\rho}{}_{\mu\nu}$$

The WeitzenbÖckconnection [12] terms and thereby torsion components are calculated.

Now energy-density and momentum can be obtained from

$$P^{(a)} = \int dV[\ e^{(a)}{}_{\mu}\, (t^{0\mu} + T^{0\mu})]$$

where (a)=(0),(a)=(1),(2),(3) correspond to energy, momentum components .

2.Newtonian Gravity:

It is remarkable that gravity, probably the fundamental interaction, still remains the most enigmatic even though it is so related with phenomena experienced in everyday life. Under the microscope of experimental investigation, gravitational interaction was the first one to be put under.

Gravitational force acts between all masses. The closer together the two objects, larger their masses are the greater the force of attraction between them. Gravitational force has an important property –whenever particles with different masses and different compositions move under the influence of it-all of them acquire the same acceleration and if their initial conditions are same they follow the same path. The fact that the planets move round the sun in ellipses indicates that gravitational forces are acting.

At the end of the 16^{th} century, Galileo Galilei first introduced pendulums and inclined planes. Galileo put forward the necessity of experiment in the study of science and gravity played an important role there. However, in 1665 only, when Sir Isaac Newton introduced the "inverse square gravitational force", we could connect the terrestrial gravity with celestial gravity in a single theory. His "Inverse-square law" could correctly predict the outcomes for a variety of phenomena including terrestrial experiments and planetary motion. Newton's gravitational theory incorporated two key ideas i) the idea of absolute space where space is viewed as fixed unaffected structure ii) the coincidence of inertial and gravitational mass which was later called weak equivalence principle.

The history of physics from ancient time to the modern day, is focusing on space and time. English natural philosopher Issac Newton combined Keplar's law of planetary motion with Galileo's law of falling bodies on the 1600s. This shows how the same laws apply to things on earth and things in space.

NEWTONS THREE LAWS OF MOTION:

NEWTON'S FIRST LAW.

NEWTON'S SECOND LAW.

NEWTON'S THIRD LAW.

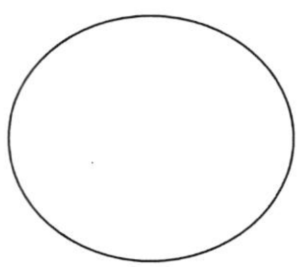
THE CONSERVATION OF MOMENTUM.

NEWTONS FIRST LAW:

Newton's first law of motion states that, objects continue to move in a state of constant velocity , which can be zero , unless acted upon by an external force. The tendency of an object to resist a change in motion is known as inertia.

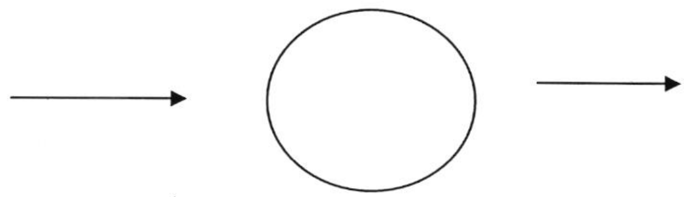
With no outside forces ,

a stationary object will never



move

with no outside force a moving object will never stop.



NEWTON'S SECOND LAW:

Newton's second law shows how an object will be affected if an external force act upon it. This law states that the rate of change of momentum of a body is proportional to the resultant force acting on it, and will be in the same direction.

That is, force = $\frac{momentum}{time}$

$$F = \frac{p}{t}$$

Momentum = mass * velocity

Acceleration = $\frac{velocity}{time}$

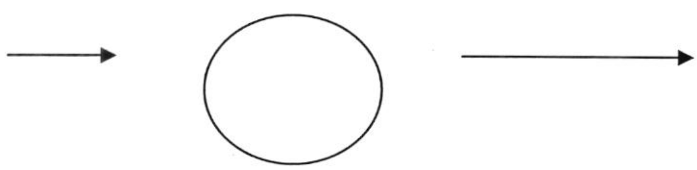
Therefore, Newtons second law can be stated as ,

Force = mass * acceleration

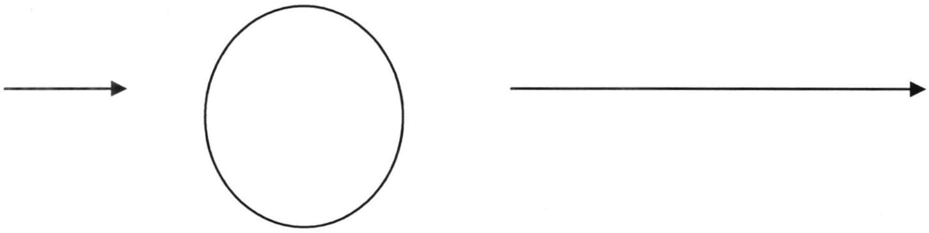
If force is "F" , mass is "m" and acceleration is "a" , so that

F = m*a

This shows that less force is needed to push something lighter which means that less massive object have less inertia.



More force, more acceleration.



NEWTON'S THIRD LAW:

Newton's third law states that the force on an object is always due to another object, all forces act in pairs that are equal in magnitude and opposite in reaction.

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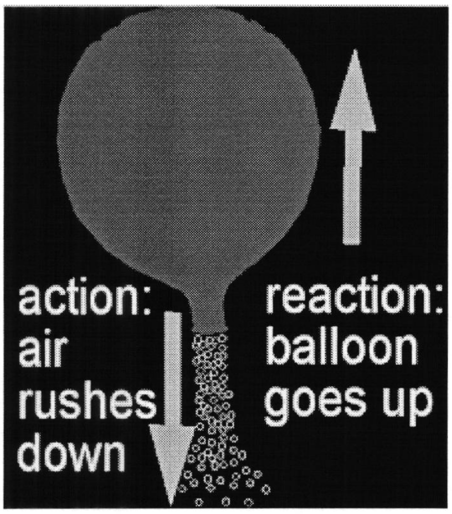


Every action has an equal and opposite reaction

THE CONSERVATION OF MOMENTUM:

The combination of Newton's second law and third law shows that momentum must be conserved. This means that the total momentum of two objects will remain the same before and after a collision.

This is because,

If $F = ma$

and

$F = -F$

then, $ma = -ma$,

$a = \frac{v}{t}$

so,

$\frac{mv}{t} = -\frac{mv}{t}$;

where, v is the velocity.

NEWTON'S LAW OF UNIVERSAL GRAVITATION:

Newton's law of universal gravitation states that, every mass attracts every other mass in the universe using a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Spherical objects like planets and stars act as if all of their mass is concentrated as their centre, and so the distance between objects should include the distance to the centre of both objects.

Newton stated that the force of gravity is always attractive, work instantaneously at a distance and has a infinite range. It account for both the downward force caused by the pull of the earth (described by Galileo) and the force that causes the planets to orbit the sun (described by keplar).

Newton's law of gravitation states that objects with different masses fall at the same rate when combined with his second law of motion. This is because an object's acceleration due to the force of gravity only depends on the mass of the objects that is pulling it.

That is, $F \infty m_1m_2$

And, $F \infty \frac{1}{R^2}$

That is, $F = G\frac{m_1 m_2}{R^2}$

Here, G is a constant that's the same for everything in the universe known as gravitational force constant. R is the radius, m_1 is the mass of the less massive object (feather or hammer) and m_2 is the mass of the more massive object (planet).

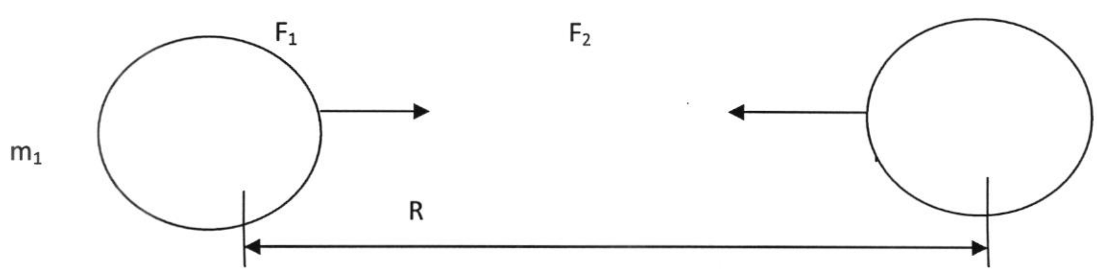
If, $F= m_1a$

and $F = G\frac{m_1m_2}{R^2}$

Then $m_1a = G\frac{m_1m_2}{R^2}$,

and $a = G\frac{m_2}{R_2}$

This means that a feather or hammer will fall at the same rate when there is no air resistance. This is a general physical law derived from empirical observations by what Newton called inductive reasoning. This was first formulated in Newton's work Philosophiae Naturalis Principia Mathematica , first published on 5 july, 1687.



$$F_1 = F_2 = G\frac{m_1 m_2}{R^2}$$

Example of Newtonian Gravity:

In 1728, Newton demonstrated the universality of the force of gravity with his cannonball thought experiment. Here Newton imagined a cannon on top of a mountain. Without gravity, the cannon ball should move in a straight line. If gravity is present then its path will depend on its speed. If it slow, then it will fall straight down. If it reaches the orbital speed, then it will orbit the earth in a circular or ellipse, and if it faster than the escape velocity, which is about 11 km/s on earth, then it will leave the earth orbit.

THE FALL OF AN APPLE:

If a man was standing on the earth and drop an apple, then the force of the earth on the apple is

$$F = G\frac{M_{earth}M_{apple}}{R_{earth^2}}$$

and apple acceleration is ,

$$a_{apple} = \frac{F}{M_{apple}}$$

$$= G\frac{M_{earth}}{R_{earth^2}}$$

$$= 9.8 \text{ meters/sec}^2$$

This means that acceleration due to gravity is independent of the mass of the apple.

EQUAL AND OPPOSITE REACTION:

Newton's 3rd law of motion states that all forces come in equal and opposite pairs.

Therefore the force that the apple apply in return upon the earth is

$$F = G\frac{M_{earth}M_{apple}}{R_{earth^2}}$$

The earth accelerates towards the apple is ,

$$a_{earth} = \frac{F}{M_{earth}} = G\frac{M_{apple}}{R_{earth^2}}$$

This can be rewritten to give the acceleration of the earth in terms of the acceleration of the apple towards the earth as

$$a_{earth} = a_{apple} * (\frac{M_{apple}}{M_{earth}})$$

Where , a_{apple} = 9.8 meters/sec^2 and the ratio of the mass of the apple to the mass of the earth is very small number.

THE MASS OF THE EARTH:

We can directly measure the acceleration of the gravity at the surface of the earth by dropping objects and timimg their fall. We find,

$$a= 9.8 \text{ meters/sec}^2$$

and radius of the earth using geometry we get

R_{earth} = 6378 kilometers

= 6,378,000 meters

Combining these together using Newton's formula for the gravitational force allows us to estimate the mass of the earth, as follows

$$M_E = a\,\frac{R_{E^2}}{G} = \frac{(9.8)(6{,}378{,}000)^2}{(6.67*10\text{^}{-11})} = 5.98*\ 10\text{^}24 \text{ kg}$$

This is an example of one of the powerful implications of Newton's law of gravity. It gives us a way to use the motions of object under the influence of their mutual gravitation to measure the masses of planets, stars, galaxies etc..

THE ORBIT OF THE MOON:

Newton's first law of motion predicts that if there were no gravitational force acting between the moon and the earth, the moon would travel in a straight line at a constant speed. But the moon moves along a curve path due to the force of gravity. This causes the moon to fall a little bit towards the earth at the same time it moves to one side.

THE FALL OF THE MOON:

Newton computed that in order to stay in its orbit, the moon must fall by 0.00136 (about 1.4mm) each second.

That is, X_{moon} = 0.00136 meters

He knew, its falls 4.9 meters in the first 1 second.

That is, X_{apple} =4.9 meters

Gravity predicts that, $\frac{X_{apple}}{3600} = \frac{4.9\ meters}{3600}$ =0.00136 meters.

This demonstrates that the same law of gravity applies to both the apple and the moon and both feel the gravity of the earth in the form of a force that gets weaker as the square of their distance from the center of the earth.

While at first sight the fall of an apple and the orbit of the moon appear to be to completely different phenomena, viewed in light of Newton's laws of motion, they are in fact different manifestations of the same thing. That is both feel a gravitational force described by the same universal force law.

The discovery of gravitation by Sir Isaac Newton, due to his observation of the falling apple explain the movements of planets and satellites not only in our solar system but also in other system as well. It explained why the earth and other planets were spherical or nearly spherical in shape.

3. Need to modify Newtonian Gravity:

In our everyday life gravity is probably the most fundamental interaction experienced by us. Under the microscope of experimental investigation, gravitational interaction was the first one to be put under.

To test the consistency of any theory as right or wrong, an appropriate way is to test how suitable is the theory for describing the physical world or even better how large a portion of the physical world is sufficiently described by this theory. In the first twenty years after the introduction of Newtonian gravity it could manage to explain all of the aspects of gravity. Newtonian mechanics specifies the way inertial frames are related to each other but it does not specify the way inertial frames are related to the physical properties of the universe.

However, in 1893,Mach the connection between the local inertial frames and the distant matter is a necessary one.This is in contradiction with Newton's ideas according to which inertia was always relative to the absolute frame of space. Again Dick stated that the gravitational constant should be a function of the mass distribution in the universe. This idea is absolutely different from the Newton's idea of the gravitational constant as being universal and unchanging.

Space-time according to Newtonian mechanics:

In physics, space-time is a continuum which combines space and time .It describes location, shape, distances, and directionetc. at different times. The properties of space is dealt with the branch of mathematics called geometry. Geometry has evolved significantly throughout the years from Euclidean geometry to Riemannian geometry. Until the turn of 20^{th} century, the 3D geometry was distinct from time. Space and time were regarded as different entities according to Newtonian mechanics to describe any event following some laws of Physics.

4.Einstein's Special Theory of Relativity:

The theory of relativity usually encompasses two interrelated theories by Albert Einstein: special relativity and general relativity. Special relativity applies to elementary particles and their interactions, describing all their physical phenomena except gravity. In physics, special relativity (SR, also known as the special theory of relativity or STR) is the generally accepted and experimentally well-confirmed physical theory regarding the relationship between space and time.

In Albert Einstein's original pedagogical treatment, it is based on two postulates:

i)The laws of physics are invariant in all inertial systems (non-accelerating frames of reference). The laws of physics all take the same identical form for all frames of reference in uniform relative motion.

It is a direct consequence of the absence of an absolute or a fixed frame of reference. For, if the laws of physics were to take on different forms in different frames of reference, it would be easily inferred from these differences as to which of them are at rest and which in motion. But, as we have seen, such distinction between the state of rest and of uniform motion is precluded by the absence of a universal frame of reference. The first postulate is thus merely a generalized statement of this observed fact.

The speed of light in a vacuum is the same for all observers, regardless of the motion of the light source.

The velocity of light in free space is the same (c) relative to any inertial frame of reference that is, it is invariant to transformation from one inertial frame to another. Einstein's special theory of relativity thus postulated that speed of light is constant for all observers in different inertial frames which is thus in dependent of velocity of light source or observer.

It was originally proposed in 1905 by Albert Einstein "on the Electrodynamics of Moving bodies". A defining feature of special relativity is the replacement of the Galilean transformation of Newtonian mechanics with the Lorentz transformations. Time and space cannot be defined separately from each other. Rather they interwoven. Einstein discerned two fundamental propositions that seemed to be the most assured, regardless of the exact validity of the (then) known laws of either mechanics or electrodynamics. These were the constancy of the speed of light and the independence of the physical laws from the choice of inertial system. The space-time transformation

As stated above in 1905, Einstein's special theory of relativity postulated that speed of light is constant for all observers in different inertial frames which is thus independent of velocity of light source or observer.

Einstein's new principle of the constancy of speed of light requires one to discard common-sense notions of space and time. The distortions of space and time have a profound effect on the laws of mechanics .The distortions of space and time intervals predicted by theory of relativity implies that space and time are parts of Physics rather than an arena in which Physics takes place. Acceptance of Einstein's special theory of relativity meant abandoning not only the Newtonian concepts of space and time and laws of mechanics but also Newton's theory of gravity. Space and time co-ordinates followed Lorentz transformation equations introduced by Einstein for observers moving relative to each other.

In 1908, Hermann Minkowski extending the work of Einstein presented a geometric interpretation of special theory of Relativity that fused time and the three spatial dimensions into a single four-dimensional continuum. The resultant space-time came to be known as Minkowski space. The space-time interval is found to be independent of the inertial frame of reference in which they are measured.

Thus

$$x'^2 + y'^2 + z'^2 - c^2 t'^2 = x^2 + y^2 + z^2 - c^2 t^2$$

Newton's theory of gravity suggest gravitational forces act instantaneously across space. Thus, it implies that gravitational effects travel faster than light and thereby violates the theory of relativity.

5. Einstein's General Theory of Relativity:

Einstein then set out to generalize the theory of relativity and constructed the theory of gravitation. General relativity explains the law of gravitation and its relation to other forces of nature. It applies to the cosmological and astrophysical realm, including astronomy. Einstein established that the equivalence of acceleration and gravitation is the fundamental principle of nature. His general theory of relativity treats the gravitational force as a field of geometrical distortion, a curvature or wrapping of spacetime.According to this theory gravitational forces are not forces acting on freely falling bodies but are instead regarded as following the shortest possible path which is called geodesic in an underlying curved space-time.

Einstein's GR is a modern geometrical theory of gravity which incorporates the mathematical model of the physical space-time.

Gravity is a wraping of spacetime:

Special theory of relativity is concerned only with inertial frames of reference, i.e., frames that are not accelerated or the systems moving with constant velocity. In 1916, Albert Einstein gave General Theory of Relativity which goes further by including the effects of acceleration. General relativity (also known as the general theory of relativity or GTR) generalizes special relativity and Newton's law of universal gravitation, providing a unified description of gravity as a geometric property of space and time, or spacetime.

In our everyday world, Newton's law of gravitation is a perfectly good approximation. But it fails to explain many phenomena like gravitational lensing, gravitational redshift etc. Even Special Theory of Relativity cannot explain these phenomena. To give the perfect explanation about these phenomena, Einstein gave General theory of Relativity. According to General Relativity the laws of physics may be expressed in equations having the same form in all frames of reference, regardless of their states of motion. Thus the General Theory covers accelerated as well as uniform motion due to which it is able to describe different gravitational phenomena. It also states that there is no way for an observer in a closed laboratory to distinguish between the effects produced by gravitational field and those produce by an acceleration of the laboratory and it is called the 'principle of equivalence'.

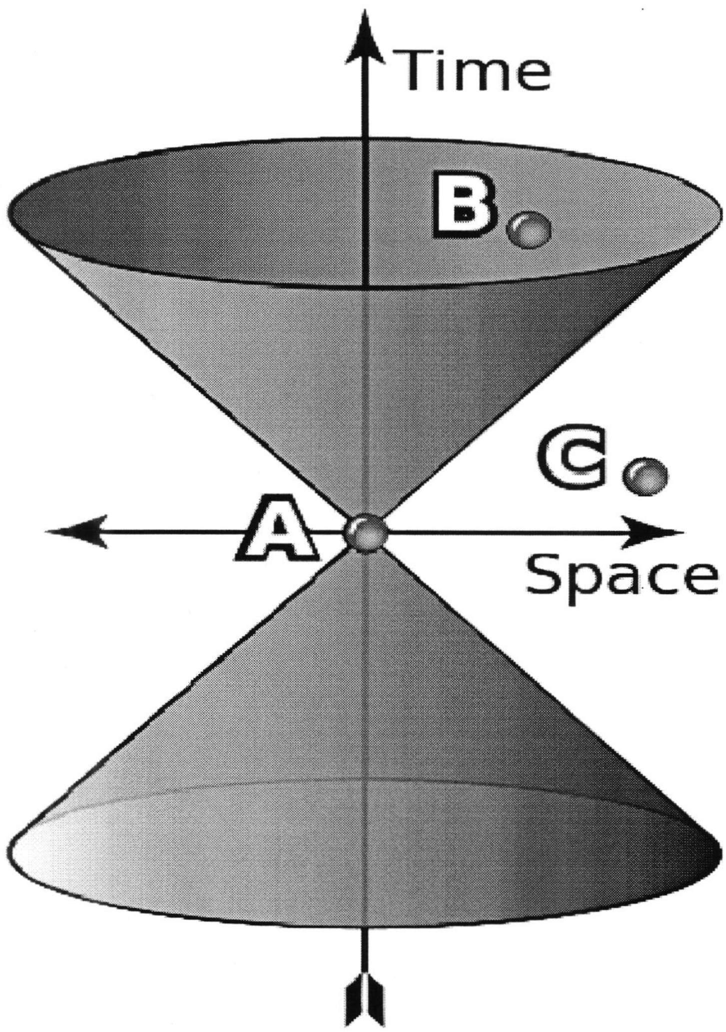
Though the predictions of General Relativity have been confirmed in all observations and experiments to date, but it is not the only relativistic theory of gravity. It is the simplest theory which is consistent with the experimental data found from different gravitational phenomena. General Relativity also predicts the existence of gravitational wave. The first detection of gravitational waves after a century of his prediction with the help of a powerful detector called LIGO from a pair of black holes merging. In addition, General Relativity is the basis of current cosmological models of a consistently expanding universe.

General Relativity replaces the scalar gravitational potential of classical physics by a symmetric rank-two tensor, the latter reduces to the former in certain limiting cases. For weak gravitational fields and slow speed relative to the speed of light, the theory's predictions converge on those of Newton's law of universal gravitation. As it is constructed using tensors, general relativity exhibits general covariance. Furthermore, the theory does not contain any invariant geometric background structures, i.e. it is background independent. Having formulated the relativistic, geometric version of the effects of gravity, the question of gravity's source remains. In Newtonian gravity, the source is mass. In special relativity, mass turns out to be part of a more general quantity called the energy–momentum tensor, which includes both energy and momentum densities as well as stress (that is, pressure and shear). Using the equivalence principle, this tensor is readily generalized to curved space-time.

The metric function and its rate of change from point to point can be used to define a geometrical quantity called the 'Riemann curvature tensor', which describes exactly how the space or spacetime is curved at each point. Einstein used Riemann curvature tensor and the metric to define a geometrical quantity G, called the 'Einstein tensor', which describes some aspects of the way spacetime is curved. Einstein's equation then states that

$$G_{\mu\vartheta} = \frac{8\pi G}{c^4} T_{\mu\vartheta}$$

i.e., up to a constant multiple, the quantity $G_{\mu\vartheta}$ (which measures curvature) is equated with the quantity $T_{\mu\vartheta}$ (which measures matter content).



Here G is the gravitational constant of Newtonian gravity and c is the speed of light.

6. Space-Time from Newton to Einstein:

In physics, space-time is a continuum which combines space and time .It describes location, shape, distances, direction etc at different times. The properties of space is dealt with the branch of mathematics called geometry. Geometry has evolved significantly throughout the years from Euclidean geometry to Riemannian geometry. Until the turn of 20^{th} century, the 3D geometry was distinct from time. Space and time were regarded as different entities to describe any event following some laws of Physics.

Spacetime, in Physics, is any mathematical model that combines dimensions of space and time into a continuum.

Hermann Minkowski, expanded upon Einstein's work which presents a geometric interpretation of spacetime, fusing Einstein's model into a unified vector space of spacetime events of a single four-dimensional continuum – called Minkowski space. The geometric character of this model is embedded in the notion of the space-timeinterval that measures distance on the manifold. Einstein further developed the idea of space-time with his introduction of curved space-time in the General theory of Relativity.

It is assumed in general relativity that space-time is curved by the presence of matter (energy), this curvature being represented by the Riemann tensor. In Special theory of Relativity, the Riemann tensor is identically zero, and so the concept "Non-curvedness" is sometimes expressed by the statement- Minkowski space-time is flat.

The concepts of time-like, light-like and space-like intervals in Special Theory of Relativity can be used in a similar way to classify one-dimensional curves through curved space-time. A time-like curve can be understood as one where the interval between any two infinitesimally close events on the curve is time-like and similarly for light-like and space-like curves. Technically, the three types of curves are usually defined in terms of whether the tangent vector at each point on the curve is time-like, light-like or space-like. The world line of a slower-than-light object will always be a time-like curve, the world line of a mass-less particle such as a photon will be a light-like curve and a space-like curve could be the world line of a hypothetical tachyon. In the local neighbourhood of any event, time-like curves that pass through the event will remain inside that event's past and future light cones, light-like curves that pass through the event will be on the surface of the light cones, and space-like curves that pass through the event will be outside the light cones. One can also define the idea of a three dimensional "space-like hyper surface", a continuous three-dimensional slice through the four dimensional property with the property that every curve which is contained entirely within this hyper surface is like a space-like curve.

The presence of gravity greatly complicates the description of space-time. In General Relativity, space-time is no longer a static background, but actively interacts with the physical systems that it contains.

Space-time curves, in the presence of matter, can propagate waves, bends light and exhibits a host of other phenomena.

The curvature of space-time is simply called gravity. In relativity, we don't so much draw squares and circles but use a version of the Pythagorean Theorem to measure distances between points in space-time, and is called the "space-time interval". When our space-time interval does not make proper Euclidean triangles, then we say our space-time is curved.

The following equation is one of the general relativistic versions of the Pythagorean Theorem, it is formally called the Schwarzschild metric (line element technically) and is a solution to Einstein's field equations and named after Kari Schwarzschild who first derived it.

It is the sum of individual "lengths" squared and the coefficients vary depending from place to place and this variation in the Pythagorean theorem, or non-uniform distances between points is exactly what we mean by "space-time being curved".

$$c^2 d\tau^2 = [-c^2(1 - \frac{2GM}{r})]dt^2 + [\frac{1}{1 - \frac{2GM}{r}}]dr^2 + [r^2]\, d\Omega^2$$

The gravity around Earth is mostly due to time curvature. If we look a lot the equation above, the time curvature is the math in front of "dt", "t" is time and the curvature of space is everything else. Here c, 2, G, M are all constants but "r" is the position which can vary. When we choose different values of "r", we get different values of the coefficients of the equation.

7. Different types of universe:

The speculations about the nature of the universe are as old as man himself. It has been of great interest to extend the application of general theory of relativity and teleparallel theory of gravitation (TEGR) to the universe as a whole.

In cosmology the identification of our universe with Friedmann –Lemaitre –Robertson Walker (FLRW) space-time is largely based on the high degree of isotropy measured in the cosmic microwave background. Spatially homogeneous and anisotropic cosmological models play a significant role in the description of large-scale behaviour of the universe. In search for a realistic picture of the early universe such models have been widely studied within General Relativity (GR).In this work we restrict our review work to Kantowski-Sachs, Bianchi type I space-time.

8. Gravity beyond General Relativity:

According to General Relativity, space-time is fully described by metric alone. The equations of motion of GR describe the relation between the geometry of space-time and the energy-momentum contained on it. Therefore the metric is considered to be the only fundamental field in the gravitational action .The equations of motion can be formulated from first principles by considering the Einstein-Hilbert action

$$S_{GR}(g^{\mu\nu}) = \int d^4X \sqrt{-g}\; g^{\mu\nu}R_{\mu\nu}$$

$$= \int d^4X \sqrt{-g}\; R$$

In metric formalism .Varying with respect to the metric gives us the Einstein's equations

$$R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu}R = 8\pi G\, T_{\mu\nu}$$

where $T_{\mu\nu}$is the energy-momentum tensor (the source of gravitational field) and describes the energy content of the universe under consideration ,

G → Newtonian Gravitational constant

Einstein's relativistic theory corresponds to Newton's theory in the non-relativistic approximation of a weak, static gravitational field.

According to Newton's theory of gravitation the field equation in the presence of matter is given by

$$^2\phi = 4\pi G\rho$$

where ϕ is the gravitational potential and ρ is the density of matter.

The mathematical model of the physical space-time in GR originated from Einstein's Equivalence principle which incorporates the universality of free fall of the test bodies in a gravitational field.The physical foundations and standard formulation of GR have very good observational evidence .observational consequences of the Einstein's equations were confirmed up to 0.003% in solar system (weak gravitational field) and up to 0.05% in binary pulsars (strong gravitational field). Universality of free fall was confirmed up to 10^{-14} and some other consequences of EEP were confirmed up to 10^{-23} [ ].

Universality of both gravitational and inertial effects was one of the key factors considered by Einstein in the way towards the gravitational theory.

Gravitational field was thus considered as a change in the metric of space-time . We know in an inertial reference system (in absence of forces) in Cartesian co-ordinates the interval dS is given by

$$dS^2 = (cdt)^2 - (dx^1)^2 - (dx^2)^2 - (dx^3)^2$$

$$= C^2 dt^2 - dx^2 - dy^2 - dz^2$$

Mechanical phenomenon can be suitably described in this differential geometric framework by using a Lorentz metric and geodesic equation

$$d^2 x^\mu / d^2$$

In a non-inertial system of reference, the square of an interval appears as

$$dS^2 = g_{ik}\, dx^i\, dx^k$$

where g_{ik} are certain functions of space-time co-ordinates x^1 , x^2 , x^3 ,x^0 .The quantities g_{ik} represent the space-time metric.

This is a quadratic form of general type in the co-ordinate differentials, that is, it has the form We know a non-inertial system of reference is equivalent to a certain field of force. In relativistic limit, these fields are determined by the quantities g_{ik} .The same applies to actual gravitational fields. An actual gravitational field cannot be eliminated by any transformation of co-ordinates. in other words, in the presence of gravitational field, space-time is such that the quantities g_{ik} determining its metric ,cannot by any co-ordinate transformation be brought to their Galilean values over allspace. Such a space-time is said to be curved whereas the space-time where such reduction is possible is called flat space-time.

9.Need to modify gravity according to General theory of Relativity

Einstein's General theory of Relativity lacks the definition of energy-momentum. There is no local notion of gravitational energy density in general relativity which has to do with the connection between conserved quantities and the symmetries of space-time. General relativity is a theory of space-time geometry and there are no symmetries that characterises all spacetimes.The absence of a local gravitational energy in general relativity is a [part of the shift in viewpoint from gravity as a force field operating in space-time to gravity as curved space-time. Localization of energy-momentum is a problem with this theory because according to EEP, gravity cannot be detected at a point. This means energy-momentum is fundamentally non-local and hence it is non-tensorial. In the realm of general relativity none of expressions for energy-momentum are dependent on the reference frame which is certainly not a desirable feature. In the gravitation theory of general relativity the formulation of energy and/or momentum distributions is one of the oldest ,interesting and controversial problems .The problem of finding a covariant expression for the distribution and conservation of gravitational energy-momentum for General Relativity dates back to 1910s.The first attempt to unify gravitation and electromagnetism was made by H.Weyl in 1918.Just like the continuity equation in electrodynamics

$$J^{\mu}{}_{,\mu} = 0$$

The conservation of energy and momentum is expressed by

$$T^{\mu\nu}{}_{,\nu} = 0 ,$$

Stress energy tensor is divergence less.

The laws are thus expressed as tensor quantities in Special Relativity.

To get the law of Physics in General Relativity, we are to write

$$T^{\mu\nu}{}_{;\nu} = 0$$

But this equation though a consequence of Einstein's equations is a balance equation not a conservation equation because the covariant divergence of a rank 2 tensor cannot be written using co-ordinate divergence.

Laundau and Lifshitz presented a pseudo-tensor of the gravitational field that is dependent on the second derivative of the metric tensor. An adequate transformation of co-ordinates will annul this. This is consistent with Einstein's principle of equivalence according to which we can always find a small region of space-time that prevails in the space-time of Minkowski. In such space-time, gravitational field is null.So, energy of gravitational field can be defined in a whole region of space-time but not in a small region.

Einstein was the first who tried to solve this problem by introducing energy-momentum pseudo-tensors. He established the energy-momentum conservation laws given by

$$\partial / \partial_{x\nu} \{ \surd\text{-}g \ (T^{\nu}{}_{\mu} + t^{\nu}{}_{\mu})\} = 0$$

$$(\mu,\nu = 0,1,2,3)$$

where $T^{\mu}{}_{\nu}$ is energy-momentum density of matter but $t^{\nu}{}_{\mu}$ is the energy-momentum density of gravitation.

$T^{\mu}{}_{\nu}$ is a tensor but $t^{\mu}{}_{\nu}$ is not a tensor quantity but (gravitational) pseudo-tensor.

Because it vanishes in geodesic co-ordinate system but non-zero in other co-ordinate system. This means the energy-momentum density is reference frame dependent.

The energy –momentum complexes were local objects while it was believed that the suitable energy-momentum of the gravitational field was only total. To avoid this difficulty alternative geometric models to GR were constructed out of the torsion tensor.

10.Teleparallel equivalent theory of gravity :

This is a gravity with an absolute parallelism, i.e., with curve independent parallelism of distant vectors and tensors. In this old approach (since 1928; renewed recently) the mathematical model of the physical space-time is based on Weitzenb¨ock geometry (= teleparallel geometry or geometry with absolute parallelism). The geometry of such a kind is uniquely determined by the given tetrad field .

After the first pioneering work for formulation of expression for energy-momentum written by Einstein for the gravitation field, there have been many attempts to resolve the energy momentum problem by Tolman, Papapetrou, Bergman-Thomson, Moller, Weinberg, Landau-Lifshitz etc. They adopted different types of gravitational field pseudo-tensors which are co-ordinate dependent and thus dependent on the reference frame. These energy-momentum complexes were local objects while it was believed that the suitable energy-momentum of the gravitational field was only total.

Einstein was the first who tried to solve this problem by introducing energy-momentum pseudo-tensors. He established the energy-momentum conservation laws given by

$$\partial / \partial_{x\nu}\{ \sqrt{-g} \; (T^{\nu}_{\mu} + t^{\nu}_{\mu})\} = 0$$

$(\mu,\nu = 0,1,2,3)$

where $T^{\mu}_{\nu}$is energy-momentum density of matter but $t^{\nu}_{\mu}$is the energy-momentum density of gravitation

T^{μ}_{ν} is a tensor but t^{μ}_{ν} is not a tensor quantity but (gravitational) pseudo-tensor.

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The problem of energy-momentum in General Relativity was studied in the context of teleparallel gravity.This theory is based on Weitzenbock space-time as mentioned before. Weitzenbock independently introduced a space-time that presents torsion with null curvature during 1920s.Of course the notion of torsion in space-time was introduced by Cartan .According to him ,torsion appears directly related to translations ,the curvature appears directly related to rotations in space-time.Now Weitzenbock space-time posseses a psedo-=Riemannian metric based on tetrads [R.D' Inverno ,Introducing Einstein's Relativity,Oxford,1996] (a frame or Vierbein in german) of four vectors $e^{\alpha}_{(a)}$(a=1,2,3,0) –three space-like e^{α}_{1} , e^{α}_{2}, e^{α}_{3} and one time- like e^{α}_{0} .Because of null curvature in Weitzenbock space-time we have only translation or parallelism of a tetrad field. Einstein introduced tetrads for descriptions of the gravitational field but limitations of the applicability of the tetrad formalism were felt for finding a stationary solution. Moller showed that we can obtain a tensor of gravitational energy-momentum by using Lagrangian density in terms of tetrads. Teleparallel gravity can be considered to-day a variable theory of gravitation. [H I Arcos and J G Pereira ,Int J Mod Phys : D 13,2193 (2004)].In telepatallel gravity ,there have been some attempts to show that the teleparallel gravitational energy –momentum give the same results as onbtained by using the general relativistic ones [11,12].

In 1994,Maluf established the Hamiltonian formulation of the teleparallel equoivalent of General Relativity (TEGR) wher the Lagrangian density contains quadratic torsion terms.Andrade and Pereira opined that the TEGR can be understood as a gauge theory for the translation group .In this approach ,the gravitational interaction is described by a force similar the Lorentz force equation of Electrodynamics with torsion playing the role of force.

We intend to bring the implication of non-diagonal tetrads in calculating the energy-momentum in different types of universes having time dependent metric potentials.

11. Results:

The general diagonal line element can be given as

$dS^2 = -A^2 (t,x,y,z)\, dt^2 + B^2 (t,x,y,z)\, dx^2 + C^2 (t,x,y,z)\, dy^2 + D2\, (x,y,z,t) dz^2$

where A,B,C,D can be chosen properly.

For Kantowski-Sachs model ,one needs to choose

$A^2 (t,x,y,z) = B^2 (t,x,y,z) = C^2 (t,x,y,z) = 1\,,\; D^2 (t,x,y,z) = \text{Sin } y$

Here

Energy density

$U^{(1)} = K' \, \partial/\partial y[\cos y / \sqrt{\sin y}]$

$\quad = (1 + \text{Sin}^2 y) / [8\pi G (\text{Sin} y)^{3/2}]$

Also

$P^{(1)} = P^{(2)} = P^{(3)} = 0$

The momentum components are therefore individually zero.

In spherical polar co-ordinates, the inflationary universe described by Kantowski-Sachs space-time has the line element

$$dS^2 = dt^2 - \lambda^2 dr^2 - K^2 \, [d\theta^2 + \text{Sin}^2\theta \, d\phi^2]$$

where λ, k are functions of time only.

Taking the non-zero vierbeins as diagonal elements

We get the total energy as finite if r is finite and infinite for large r. Also the momentum components are found to be zero.

12.Conclusion:

Using the gravitational tensor in teleparallel equivalent of General Relativity, we analyse the different forms of Kantowski-Sachs universe .

We observe that with time dependent Kantowski-Sachs cosmologyand diagonal elements as vierbeins the energy is finite for a finite region irrespective of the equations of state of the cosmic matter while it becomes infinite for a large universe which is unphysical. The momentum components are zero and the total momentum is zero.

But with time independent Kantowski-Sachs universe in Cartesian co-ordinates and diagonal vierbeins, the momentum components and hence total momentum is zero.The energy density being zero, the total energy has value zero whether the universe is finite or infinite.