Variation of "g"

1. Variation of g

a) Rotation and Shape of the earth

- Earth is flat at the poles and bulged at the equator. The polar radius is lesser than the equatorial radius by 2s1 km. Hence g is greater at the poles than at the equator.
- Due to the spin of the earth, more centrifugal force acts on bodies near the equator. Hence g value is less at the equator.
- The value of g near the equator is 9.78 ms^{-2} and near the poles it is equal to 9.83 ms^{-2} and is zero at the centre of the earth.
- Spin of the earth does not affect the value of g at the poles.
- If the earth stops spinning, g increases slightly near the equator.
- If the earth spins at 17 times the present speed, g becomes zero at the equator.

b) Latitude

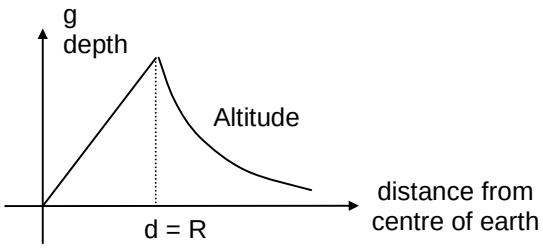
- Variation of g latitude angle ϕ is given by, $g_\phi = g - R\omega^2 \cos^2\phi$
- At poles $\phi = 90^0$, $g_\phi = g$
- At the equator $\phi = 0^0$, $g_\phi = g - R\omega^2$

c) Height and Depth

a) Acceleration due to gravity at a height 'h' is $g_h = g\left(\frac{R}{R+h}\right)^2 \cong g\left(1-\frac{2h}{R}\right)$.

b) Acceleration due to gravity at a depth d is $g_d = g\left(1-\frac{d}{R}\right)$

Where R is the radius of the earth



c) At the centre of the earth acceleration due to gravity and weight of the body is zero.

2. Gravitational Field

a) Gravitational force exists even when the particles have no physical contact. This is called action at a distance or force at a distance.

b) To overcome the difficulties in the gravitational law, field concept is introduced.

c) The space around a body in which its influence is there is called gravitational field.

d) The gravitational intensity $I = \frac{GM}{r^2}$. This magnitude is numerically equal to 'g'. Unit is same as that of 'g'. This is a vector.

e) Zero intensity point from the least mass is given by, $x = \frac{Total\ separation}{\sqrt{m_2/m_1} + 1}$

f) Gravitational potential (V) = $\frac{GM}{r}$.

g) Gravitational PE = $-\frac{GMm}{r} = -mgr$.

h) Gravitational KE = $\frac{GMm}{2r} = \frac{mgr}{2}$.

i) Gravitational Total energy = $-\frac{GMm}{2r} = -\frac{mgr}{2}$.

2. Propagation of gravitational fields

a) According to Einstein, gravity is because of distortion of space time due to the presence of matter.

b) According to General theory of relativity whenever mass particles are accelerated, the gravitational field around them changes and they are said to produce gravitational waves, which are ripples in space time.

c) It is difficult to detect gravitational waves, but there are observational consequences such as near a pulsar, Black hole or when a massive star undergoes a gravitational collapse.

d) According to quantum theory all fields are quantum in nature including gravity. According to quantum theory of gravity, gravitational force between two mass particles is mediated by a particle called graviton.

e) A graviton has zero rest mass, travels with the velocity of light; therefore gravitational field propagates with the velocity of light.

3. Frames of reference

i) Inertial frames

a) In these frames Newton Laws of motion are applicable.

b) These move with uniform velocity relative to each other.

c) All fundamental forces of nature are real.

d) Observers in all inertial frames measure the same acceleration for a given object but might measure different velocities

ii) Non - Inertial frames

a) In these frames Newton Laws are not applicable.

b) Pseudo force exist for observers only in non - inertial frames, such forces have no existence relative to an inertial frame.

c) If $\vec{a}$ is the acceleration of a non - inertial frame. The Pseudo force acting on an object of mass m, relative to an observer in the given non- inertial frame is

$\vec{F}$Pseudo = – m$\vec{a}$

i.e. Pseudo force acts on an object opposite to the direction of acceleration of the non - inertia frame.

e) **Centrifugal force:** It is a pseudo force experienced radically outward by an object relative to the object, moving in a circular path relative to an inertial frame.

Inertial mass and gravitational mass

a) **Inertial mass (m_1):** The inertial mass of a body is the ratio of the force acting on the body to the acceleration produced by the force.

b) It is difficult to measure inertial mass.

c) **Gravitational Mass (m_g):** If is the ratio of the gravitational force acting on a body to the acceleration due to gravity.

d) Gravitational mass can be measured using spring balance and common balance

e) Inertial and gravitational mass of a body are equal.

4. Principle of Equivalence

When experiments are conducted in inertial and non inertial frames under the same conditions, give the same results, the frames are to be identical. This is the principle of equivalence.