Gravitational Fields

Vinayak Arora

November 13, 2023

1 Newton's Law of Gravitation

Newton's Law of Gravitation states that any two bodies in the universe having a mass exert a force on each other. The forcce is directly proportional to the masses of the bodies.

$$F \propto M * m \tag{1}$$

Where Mass M and m are the masses of the two bodies. The force is inversely proportional to the square of the distances between them.

$$F \propto \frac{1}{x^2} \tag{2}$$

Where x is the distance between them. Combining the two we get

$$F \propto \frac{M * m}{x^2} \tag{3}$$

Adding proportionality

$$F = \frac{G * M * m}{x^2} \tag{4}$$

Where G is the gravitational constant and is equal to

$$6.67 * 10^{-11} Nm^2 Kg^{-2} \tag{5}$$

2 Gravitational Field

The gravitational Field around a body is defined as the area around which a body exerts a force of attraction. This gravitational field consists of fields of lines acting inwwards.

3 Gravitational Field Strength

The Gravitational Field Strength (g) at a point is defined as the force acting on a unit mass placed at that point. Hence

$$g = \frac{G * M}{x^2} \tag{6}$$

It is same as the acceleration due to the gravity, and gives the same units.

4 Gravitational Potential

The Gravitational Potential per unit mass at a point is the work done in bringing an object from infinity to that point. GPE is 0 at infinity, hence at a point other than infinity, the gravitational potential will be negative.

$$\phi = \frac{-G * M}{x} \tag{7}$$

5 Speed of body in a gravitational field

The speed of the body in a gravitational field can be found by equating The Centripetal force of the body of the smaller mass to the force of attraction between the two bodies.

$$\frac{m * v^2}{x} = \frac{G * M * m}{x^2} \tag{8}$$

This leads us to

$$v = \sqrt{\frac{G * M}{x}} \tag{9}$$

6 Geo Stationary Satellites

Satellites which must remain at one position over the earth are referred to as stationary orbit satellites. They must have a time period of 24 hours. We can find time period of a satellite over the earth be equation Centripetal force of a body and the force of attraction between the two bodies. Remember that

$$\omega = \frac{2 * \pi}{t} \tag{10}$$

Hence we get

$$\frac{4 * \pi^2 * x^2}{t^2} = \frac{G * M}{x} \tag{11}$$

Or

$$t^2 = \frac{4 * \pi^2 * r^3}{G * M} \tag{12}$$

6.1 Stationary Orbit

Satellite in an orbit going from West to East.