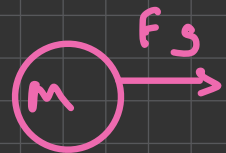


Gravitational fields are due to objects having mass



$$F_g = -\frac{GmM}{r^2}$$

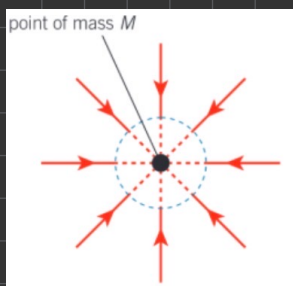
gravitational constant
 6.67×10^{-11}

$$g = -\frac{GM}{r^2}$$

$$g = -\frac{GM}{r^2}$$

modelling the mass of a spherical object as a point mass in its centre

$$g = \frac{F}{m} \text{ (Nkg}^{-1}\text{) or (ms}^{-2}\text{)}$$



Close to the surface of the earth the gravitational field can be assumed to be uniform



The density of field lines is proportional to the field strength

Kepler's laws:

1. The orbit of a planet is an ellipse with the sun at one of the foci
2. A line segment joining the sun and a planet sweeps out equal areas in equal times
3. The square of the orbital period of a planet is proportional to a cube of its distance

$$T^2 \propto r^3$$

$$T^2 = kr^3$$

constant

$$\frac{T^2}{r^3} = k$$

$$\frac{T_1^2}{r_1^3} = \frac{T_2^2}{r_2^3}$$

Kepler's 3rd law proof



centripetal force = gravitational force ($F_g = F_c$)

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$v = \frac{2\pi r}{T}$$

$$v^2 = \frac{4\pi^2 r^2}{T^2}$$

$$\frac{GM}{r^2} = \frac{4\pi^2 r}{T^2}$$

$$T^2 = \frac{4\pi^2}{GM} r^3$$

Geostationary orbits

1. They have an orbital period of 24 hours in the same direction as the rotation of the Earth
2. They are an equatorial orbit
3. They remain fixed in the sky to an observer on Earth

height of geostationary orbit from centre of earth

$$T^2 = \frac{4\pi^2}{GM} r^3$$

$$r^3 = \frac{T^2 GM}{4\pi^2}$$

$$r = \sqrt[3]{\frac{T^2 GM}{4\pi^2}}$$

height from surface = $r - \text{radius of earth}$
(6400×10^3)

$$\text{Gravitational force } F = -\frac{GMm}{r^2}$$

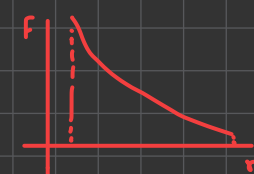
$$\text{Gravitational potential energy } \text{Energy} = -\frac{GMm}{r}$$

$$\text{Gravitational potential } V_g = -\frac{GM}{r}$$

energy per unit mass

at infinite distance they are negative and increase with distance

The gravitational potential is the work done to bring a unit mass from infinity to the point



work done is the area under the curve in a force distance graph

Escape velocity of the earth

$$GPE = KE$$

$$\frac{GMm}{r} = \frac{1}{2} mv^2 \quad v = \sqrt{\frac{2GM}{r}}$$

$$M = 6 \times 10^{24} \text{ kg} \quad r = 6400 \text{ km} \quad G = 6.67 \times 10^{-11}$$

Sub into equation = $11 \times 10^3 \text{ ms}^{-1} = 11 \text{ km s}^{-1}$