Gravitational Attraction between masses

Motion of planets (Kepler) … pure Kinematics

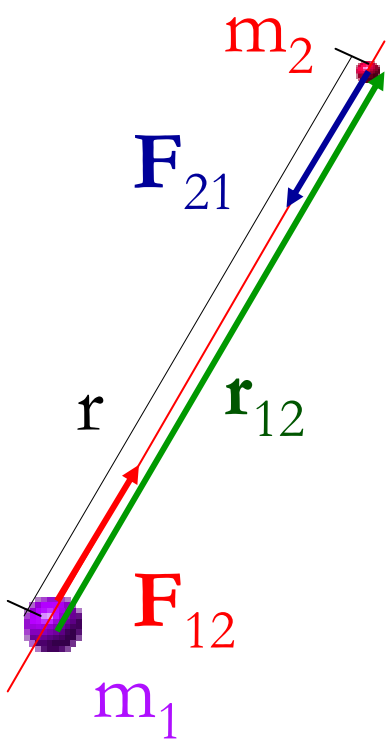
1. The orbits of planets are plane ellipsis, the Sun is in one of the focuses
2. The vector along the line Sun- Planet describes equal areas in equal times
3. The cube of the major semiaxes of a planet orbit is proportional to the square of its period

Interpretation of what causes the motion: Newton

Gravitational Actration (between masses)

Cavendish experiment

Applets



$$F_{21} \propto \frac{m_1 m_2}{r^2}$$

$$\mathbf{F}_{21} = -G\frac{m_1 m_2}{r_{12}^3}\mathbf{r}_{12}$$

$$\mathbf{F}_{21} = -G\frac{m_1 m_2}{r^2}\hat{\mathbf{r}}_{12}$$

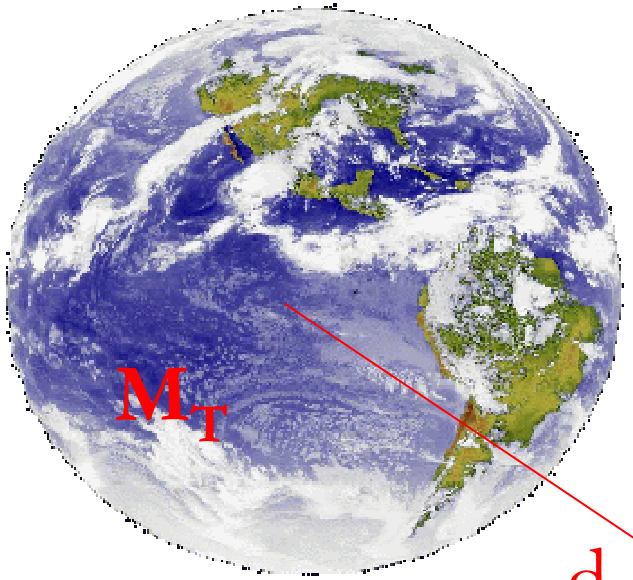
$$\mathbf{F}_{12} = -\mathbf{F}_{21}$$

$G=6.67\times10^{-11}\ \mathrm{N\,m^2/kg^2}$ universal gravitational constant

Gravitational Actration (between masses)

… but the Earth is not a point body!

It acts as if the mass was concentrated in the centre of Earth



$$\mathbf{F}_m = -G\frac{M_T}{d^2}\hat{\mathbf{r}}_T m$$

Applet

Let's put $\mathbf{g}_d = -G\frac{M_T}{d^2}\hat{\mathbf{r}}_T$

$\mathbf{F}_m = m\mathbf{g}_d$ $\mathbf{F}_m$ is called Weight

If a body is released from rest, what is its acceleration?

Gravitational Actration (between masses)

$$\mathbf{P}_m = -G\frac{M_T}{r_T^2}\hat{\mathbf{r}}_T m = m\mathbf{g}$$

$G=6.67\times10^{-11}$, $r_T=6.35\times10^{6}$,
$M_T=5.98\times10^{24}$, quanto vale g ?

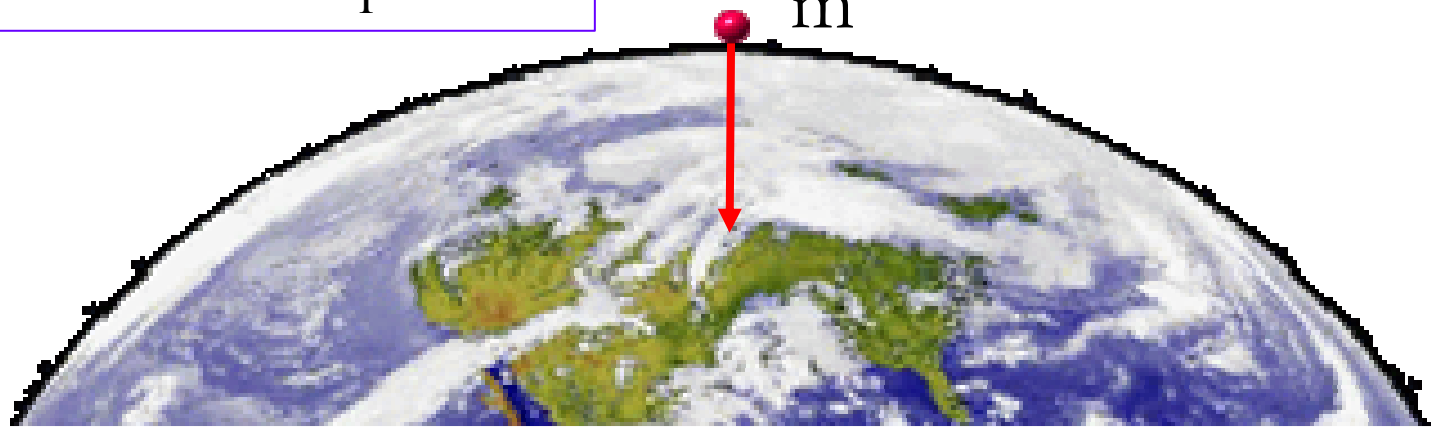
Applet

If m falls, what is its acceleration?

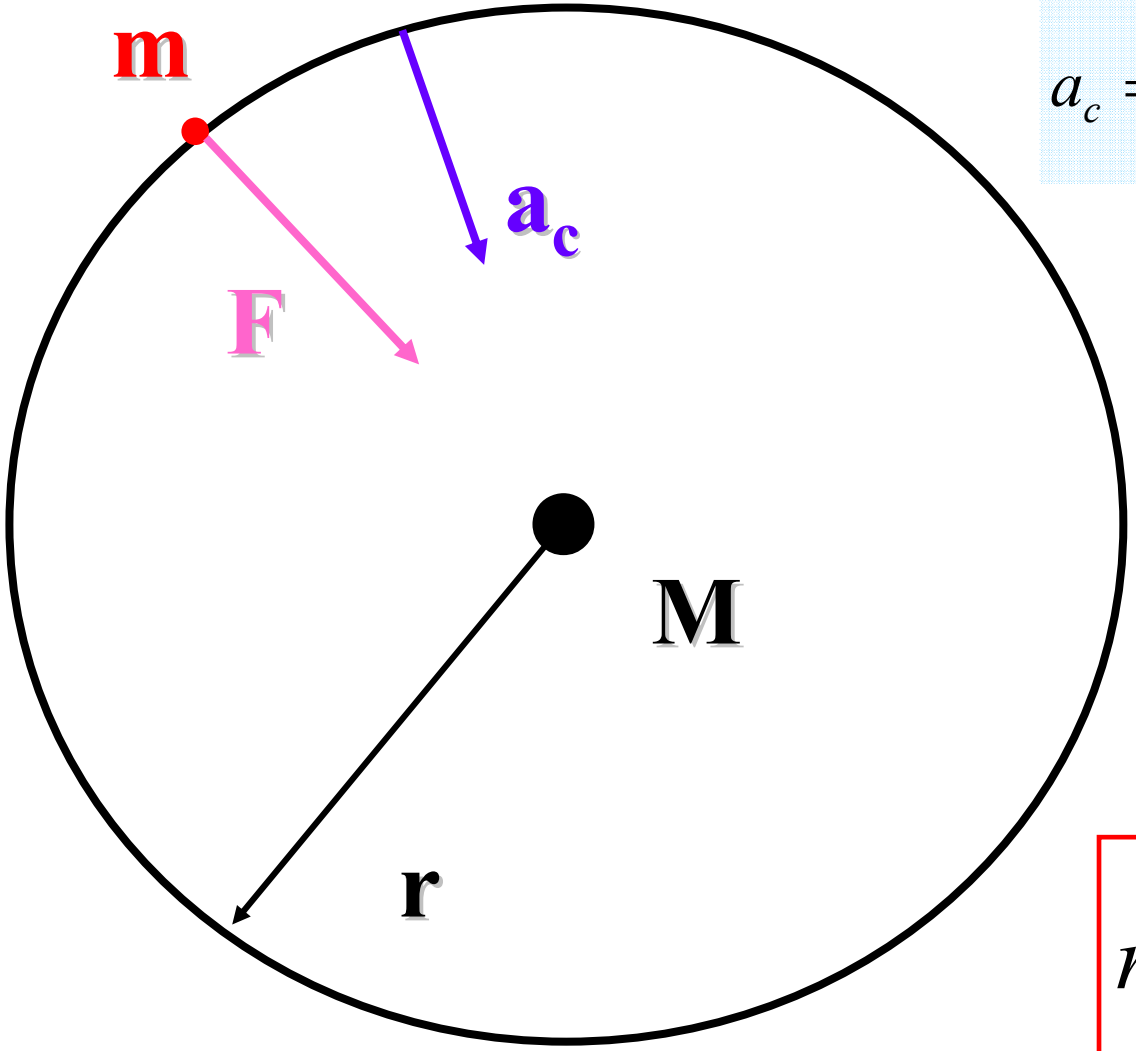
What is the force acting on the Earth ?

$$\mathbf{F}_T = -\mathbf{P}_m = G\frac{m}{r_T^2}\hat{\mathbf{r}}_T M_T$$

if $m=10^6$ kg, $a_T=1.7\times10^{-19}g$



III Law of Kepler (circular orbit)



$$a_c = \omega^2 r = \left(\frac{2\pi}{T}\right)^2 r = \frac{4\pi^2 r}{T^2}$$

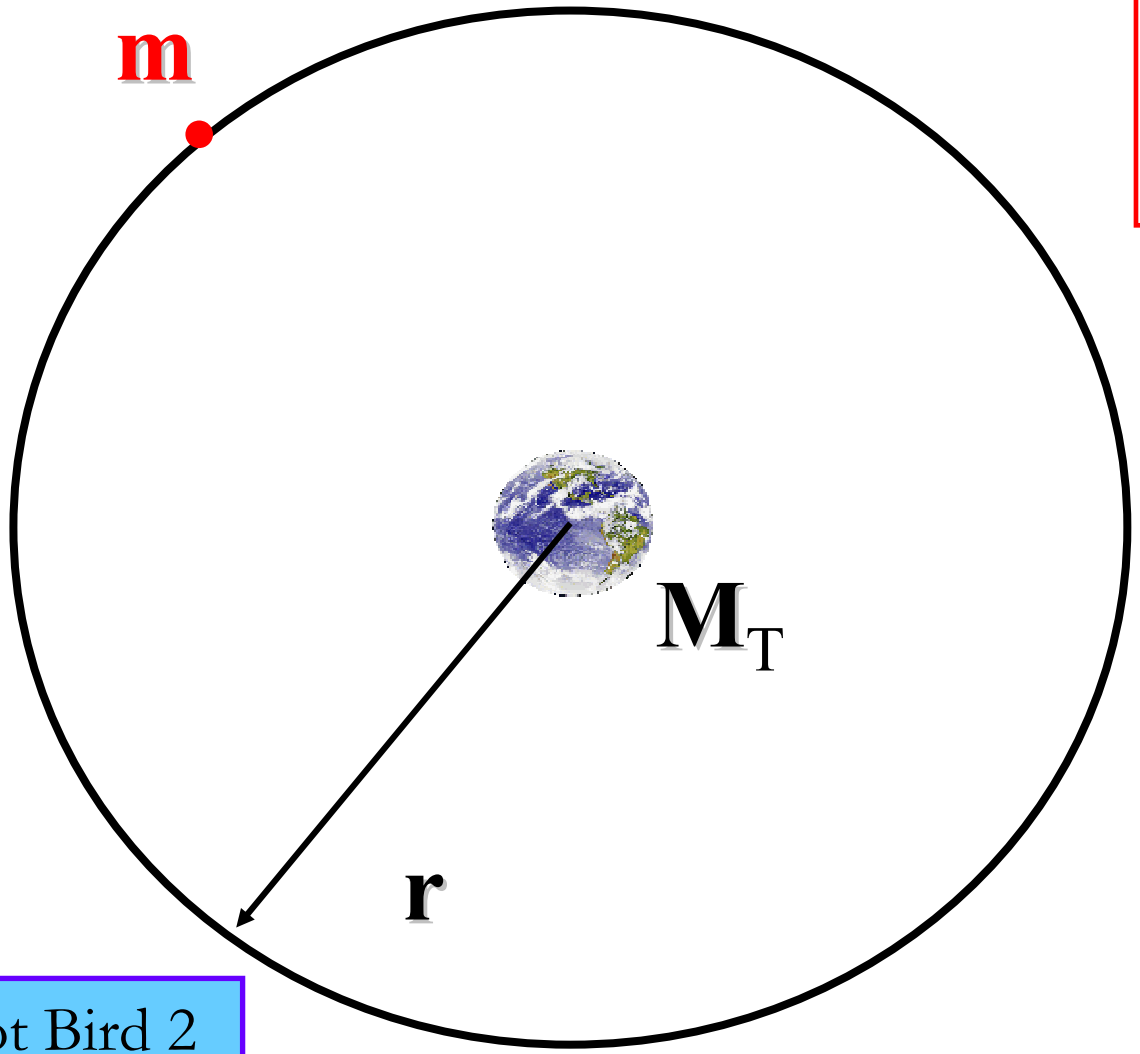
$$F = G\frac{mM}{r^2}$$

$$F = ma_c$$

$$G\frac{mM}{r^2} = m\frac{4\pi^2 r}{T^2}$$

$$r^3 = \frac{G}{4\pi^2} MT^2$$

Satellit in Geostationary Orbit (Hot Bird 2)



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

$G = 6.67 \times 10^{-11}$

$M_T = 5.98 \times 10^{24}$

$T = 24^h =$

$= 8.64 \times 10^4 s$

$r = 4.23 \times 10^7$ m

$$v\,? = \frac{2\pi \cdot r}{T}$$

$= 3.07 \times 10^3$ m/s

Hot Bird 2

Napoli: 14.3° E – 40.8° N