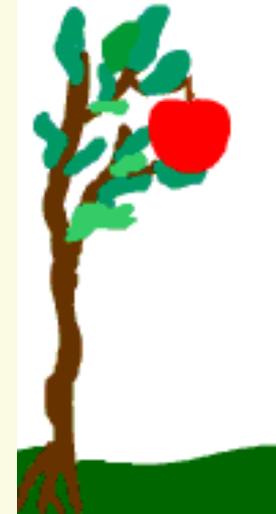
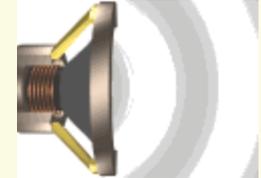


Aula 9: Gravitação

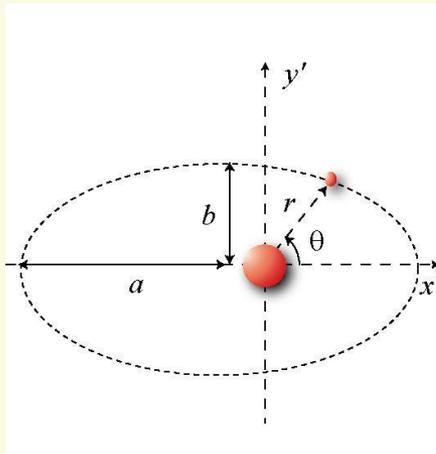
1. Leis de Kepler
2. Leis de interacção central
3. Campo e potencial gravitacional
4. Satélites
5. Velocidades cósmicas



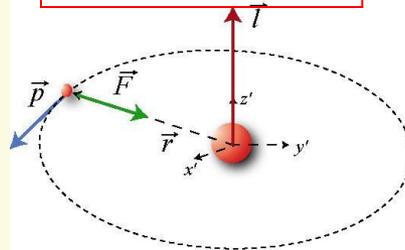
Leis de Kepler: animação



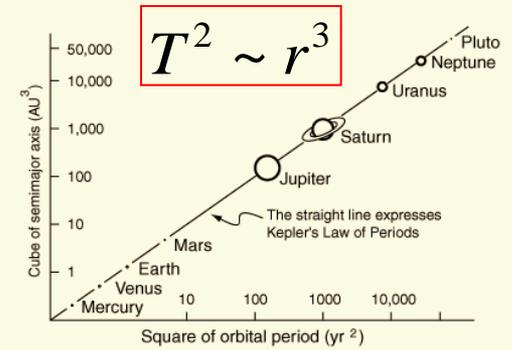
1. Leis de Kepler



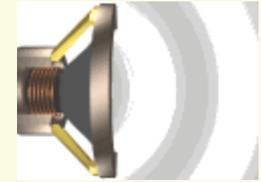
$$\frac{dA}{dt} = \frac{L}{2\mu} = \text{const}$$



$$\vec{F} = f(r) \frac{\vec{r}}{r} = f(r) \vec{e}_r$$



$$f(r) \sim \frac{1}{r^2}$$



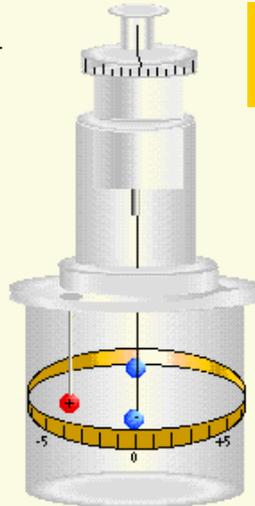
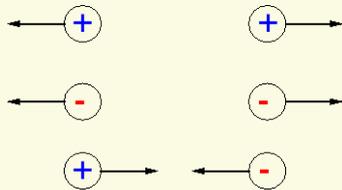
Carga eléctrica: simulação

Simulação: interacção central

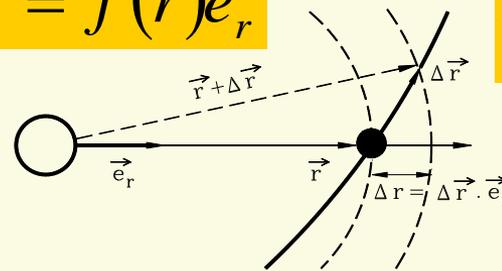
2. Leis de interacção central

$$f(r) = -\gamma \frac{m_1 m_2}{r^2} = \frac{C}{r^2}$$

$$f(r) = k \frac{q_1 q_2}{r^2} = \frac{C}{r^2}$$



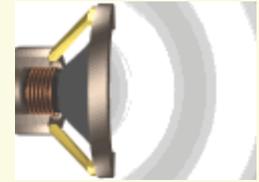
$$\vec{F} = f(r)\vec{e}_r$$



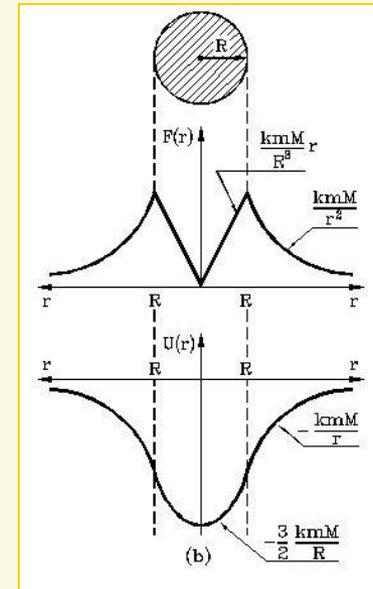
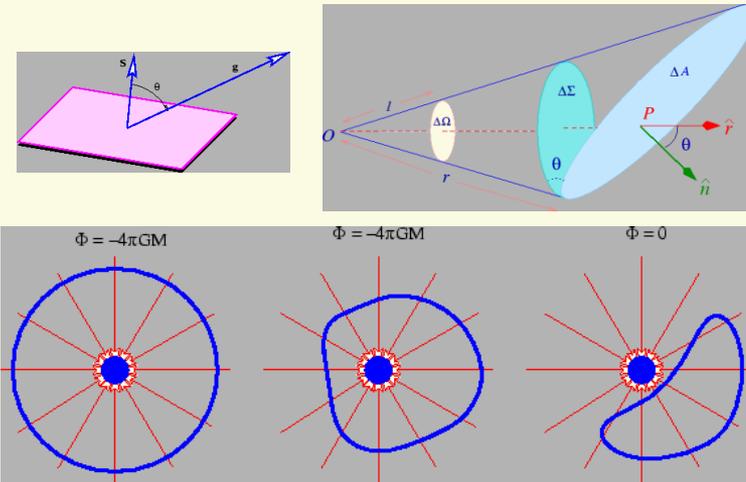
$$U(r) = \frac{C}{r} = -\gamma \frac{m_1 m_2}{r}$$

$$U(r) = \frac{C}{r} = k \frac{q_1 q_2}{r}$$

$$\frac{\text{atracção gravítica}}{\text{atracção eléctrica}} = \frac{1}{4.17 \times 10^{42}}$$



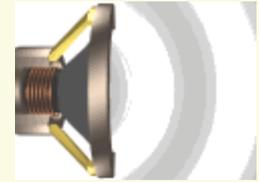
3. Campo e potencial gravitacional



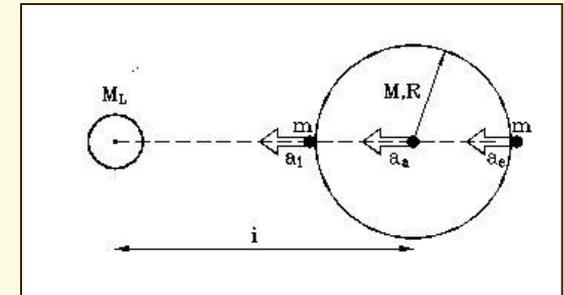
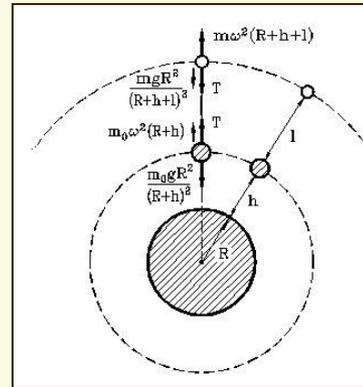
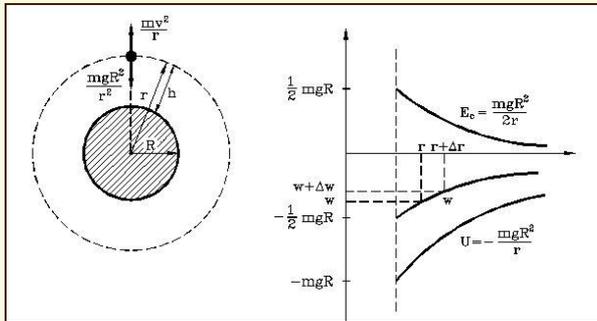
$$\vec{g} = \frac{\vec{F}}{m} = -\gamma \frac{M}{r^2} \vec{e}_r$$

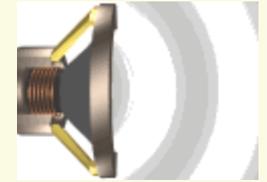
Animação: o canhão de Newton

Simulação: o canhão de Newton



4. Satélites





Simulação: velocidades cósmicas

Simulação: órbitas de um satélite

5. Velocidades cósmicas

