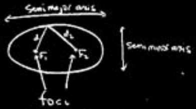
Phys 201
office "hour"
10:45 - 11:00 today




ellipse: $d_1 + d_2 = \text{constant}$

## Kepler's laws

1) All planets move in elliptical orbits with the sun at one focus.

2) Radius vector drawn from sun to planet sweeps out equal areas in equal times.

3) Square of orbit period is proportional to cube of semimajor axis of orbit

get 2) from Newton's laws

follows from conservation of angular momentum

Gravitational force is a central force, always points radially, towards sun

torque from central force is zero

$\vec{\tau} = \vec{r} \times \vec{F} = \vec{r} \times F(r)\,\hat{r} = 0$

since $\frac{d\vec{L}}{dt} = \vec{\tau}$ and $\vec{\tau} = 0$

$\frac{d\vec{L}}{dt} = 0 \Rightarrow \vec{L}$ is constant

$\vec{L} = \vec{r} \times \vec{p} = m_p \vec{r} \times \vec{v} = \text{constant}$

Relate to area swept out by orbit:



area of triangle $= \frac{1}{2}\left(\vec{r} \times \vec{v}(t)\,dt\right)$

$= \frac{1}{2}\frac{\vec{L}}{m_p}\,dt$

so $\frac{dA}{dt} = \frac{L}{2m_p} = \text{constant}$

3) $T^2 \propto R^3$ for circular orbit

$\vec{F} = m\vec{a}$   look radially

$$\frac{G m_p m_s}{r^2} = m_p \frac{v^2}{r} = m_p \omega^2 r = m_p r \left(\frac{2\pi}{T}\right)^2$$

$$\frac{G m_s}{r^2} = r\left(\frac{2\pi}{T}\right)^2$$

$$\frac{T^2}{r^3} = \frac{(2\pi)^2}{G M_s} = 2.97\times10^{-19}\,\frac{s^2}{m^3}$$

Gravitational potential energy

ch 8 : potential energy.

work done by gravitational force


$$W_g = \int_{r_1}^{r_2} \vec{F}_g \cdot d\vec{r} = \int_{r_1}^{r_2} -\frac{G m m_E}{r^2}\,dr$$

$$W_g = \frac{G m m_E}{r_2} - \frac{G m m_E}{r_1}$$

If gravity is only force,
W = change in KE

$$Gmm_E\left(\frac{1}{r_2}-\frac{1}{r_1}\right)=\frac{1}{2}mv_2^2-\frac{1}{2}mv_1^2$$

or $$\frac{1}{2}mv_1^2-\frac{Gmm_E}{r_1}=\frac{1}{2}mv_2^2-\frac{Gmm_E}{r_2}$$

identify grav. potential energy

$$U(r)=-\frac{Gmm_E}{r}$$

total mechanical energy is conserved

$$E=K+U$$

$$\frac{1}{2}mv^2-Gmm_E/r$$

Escape velocity (escape speed)

Speed needed by an object at earth's surface (ignoring dissipation) so that it just barely escapes (never comes back)

E conserved.

$$U=\frac{-Gmm_E}{r_E}$$

$$K=\frac{1}{2}mv^2$$

barely escape when $U+K=0$

after escape $E\geq 0$

barely escape when $E=0$

0

Barely escape when

$$\frac{1}{2}mv^2 = \frac{GmM_E}{R_E}$$

$$v_{esc}^2 = \frac{2GM_E}{R_E}$$

$$v_{esc} = \sqrt{\frac{2GM_E}{R_E}}$$

On earth

$$M_E = 5.98\times10^{24}\text{ kg}$$

$$R_E = 6.37\times10^{6}\text{ m}$$

$$v_{esc} = \sqrt{\frac{2(6.67\times10^{-11}\text{ N-m}^2/\text{kg}^2)(5.98\times10^{24}\text{ kg})}{6.37\times10^{6}\text{ m}}} = 1.12\times10^{4}\text{ m/s} = 25{,}000\text{ mph}$$

Look at K and U in a circular orbit

$$\vec{F} = m\vec{a}$$

$$\frac{GmM_E}{r^2} = \frac{mv^2}{r} \Rightarrow \underbrace{\frac{1}{2}G\frac{mM_E}{r}}_{\frac{1}{2}U} = \underbrace{\frac{1}{2}mv^2}_{KE}$$

$$U < 0 = 2(KE)$$

So total energy is negative

# Fluid mechanics

liquids & gases are fluids:
conform to shape of container

## 1st statics

§14.1 Pressure

in fluids, no shear stress
no tensile stress

only stress is pressure
tends to compress

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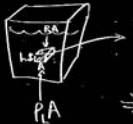
Pressure $P = \frac{\text{force}}{\text{area}}$ (magnitude)

Scalar
unit = pascal (Pa)  $1\ Pa = 1\ N/m^2$

§14.2 How Pressure varies with depth




forces on region

$-\rho g A h + P_L A - P_u A$   $\rho = \frac{\text{density}}{\text{volume}}$

$\Rightarrow P_L = P_u + \rho g h$

pressure goes up as you go down
to support fluid weight