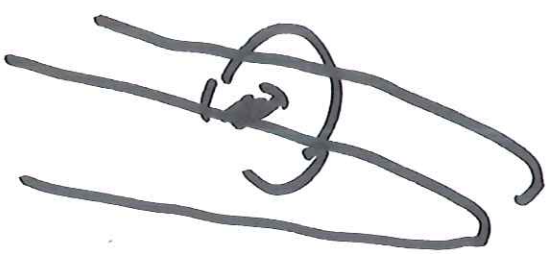
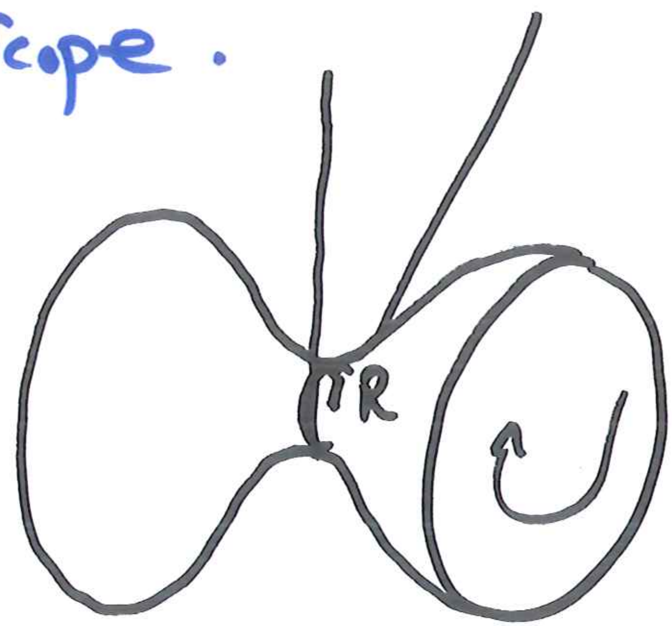
# NYU Physics I — 2016-11-15

(parallel axis thm...)

Agenda:
- Reading — Gravity, Newton's law.
  - Kepler's laws.
  - Orbits in gravity.
- Exam 5 — Scope.
- Qs
- Ballistics.

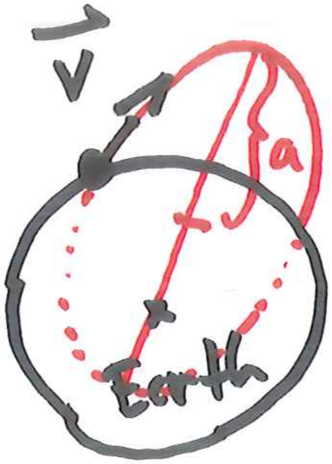




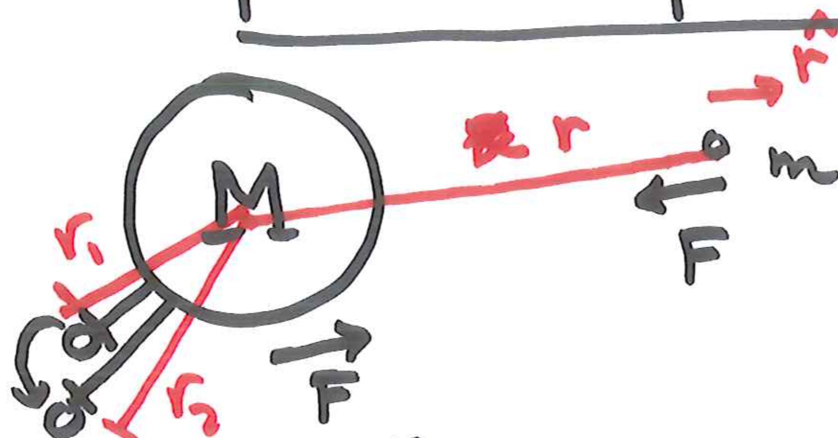
Kepler: - Ellipses / conic sections

- ~~conf~~ invariance of $\vec{L}$

- period and s.m.a. }




Newton: $$\boxed{F = -\frac{GMm}{r^2}\hat{r}}$$


$$W_{12} = \int_{r_1}^{r_2} F \cdot dr = \int_{r_1}^{r_2} \frac{GMm}{r^2}\, dr = \left[-\frac{GMm}{r}\right]_{r_1}^{r_2}$$

$$W_{12} = \frac{GMm}{r_1} - \frac{GMm}{r_2}$$

potential energy: $\boxed{U(r) = -\frac{GMm}{r}}$

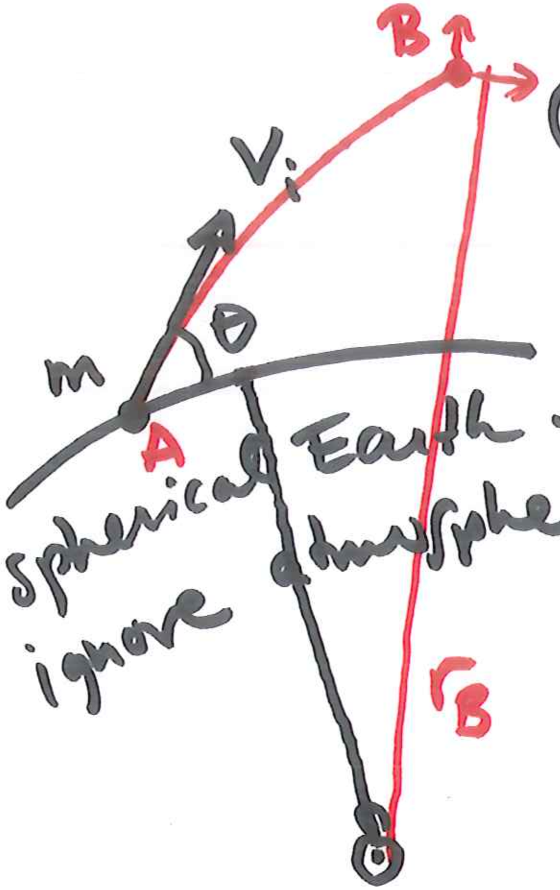
$\Delta h \updownarrow m$

$$\Delta U ? = \frac{dU}{dr} \cdot \Delta h = \underbrace{\frac{GM_\oplus}{R^2_\oplus}}_{g}\, m \, \Delta h = g\, m\, \Delta h$$

for <u>small</u> $\Delta h$,

<u>near</u> $R_\oplus$ : $mg\Delta h$.

"small" $\equiv \ll R_\oplus$




spherical Earth.
ignore atmosphere.

(A) @ launch: $KE = \frac{1}{2}mv_i^2 = \frac{1}{2}m\left[(\underbrace{v_i\sin\theta}_{rad.})^2 + (\underbrace{v_i\cos\theta}_{tan.})^2\right]$

$PE = U(R_\oplus) = -\frac{GMm}{R_\oplus}$

$L = mR_\oplus v_i\cos\theta$

recall...

<u>invariant</u>: $v_x$

(b/c. treated $\vec{g}$ as constant.)


$\vec{L} = \vec{r} \times \vec{p}$

@ path (B)

$KE: \frac{1}{2}mv_{Br}^2 + \frac{1}{2}mv_{Bt}^2$

$PE = -\frac{GMm}{r_B}$

$L = mr_B v_{Bt}$

In general:

$$\text{total } E = \frac{1}{2}mv_r^2 + \frac{1}{2}mv_t^2 - \frac{GMm}{r}$$

true potential

however: $L = mrv_t$ = invariant.

$$E = \frac{1}{2}mv_r^2 + \underbrace{\frac{L^2}{2mr^2} - \frac{GMm}{r}}_{\text{effective potential}}$$

effective potential
(b/c L is invariant.

@ $r_{max}$, $v_r = 0$

quadratic equation.

$$\boxed{E_{launch} = 0 + \frac{L_{launch}^2}{2mr^2} - \frac{GMm}{r}}$$