# Ch 4 Notes

- $F_G = \frac{G M_S M_E}{r^2}$

- Motion of Earth around sun can be converted into a differential equation.

- Use Euler-Cromer as energy in oscillatory motion is conserved or Earth spirals away

$$v_{x,y}(i) = v_{x,y}(i-1) - \frac{4\pi^2 (x, y(i))}{r_i^3} dt$$

- r must be calculated at each step

$$y,x(i) = y,x(i-1) + v_{x,y}(i)\, dt$$

- $GM_S = 4\pi^2$ - Astronomical Units

Calculate r at each step $r(i) = \sqrt{x(i)^2 + y(i)^2}$

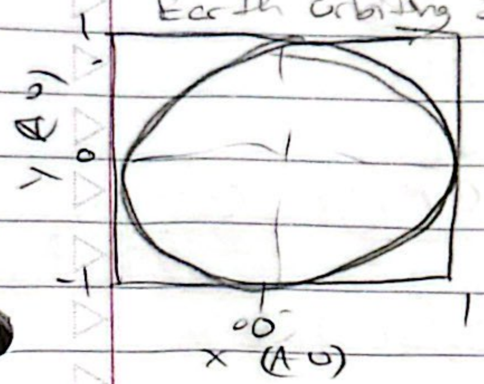
compute $v_x(i)$ and $v_y(i)$

compute $x(i)$ and $y(i)$

- Planets move in elliptical orbits with sun at one focus

- Line joining a planet to Sun sweeps out in equal areas in equal times

Earth orbiting Sun




- Keplers laws are due to gravitational force following inverse square law

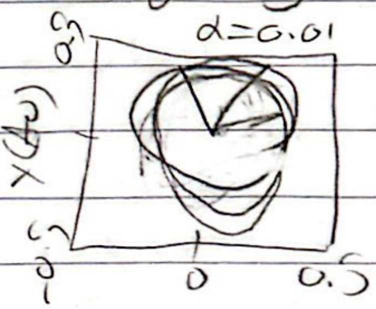
- Orbits become stable at $\beta = 2$ for $r^{\beta}$

- Mercury orbit computationally and theoretically did not agree

- This is caused by relativity

- Accounting for this we get general formula

$$v_1 = \sqrt{\frac{GM_s(1-e)}{a(1+e)}}$$




precession of mercury

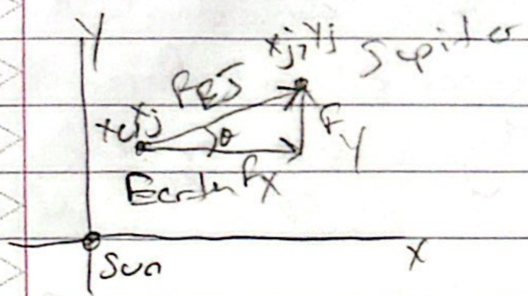
- All planets interact following inverse square

- Take Jupiter to model as it is the largest planet so the most effect on Earth

Jupiter

$$F_{EJ} = \frac{G M_J M_E}{r_{EJ}^2}$$

Jupiter to Earth




$$\frac{dv_{x_e}}{dt} = -\frac{G M_S x_e}{r^3} - \frac{G M_J (x_e - x_j)}{r_{EJ}^3}$$

Earth to sun

Calculate distances

$$r_e(i) = \sqrt{(x_e(i))^2 + (y_e(i))^2}$$

$$r_j(i) = \sqrt{(x_j(i))^2 + (y_j(i))^2}$$

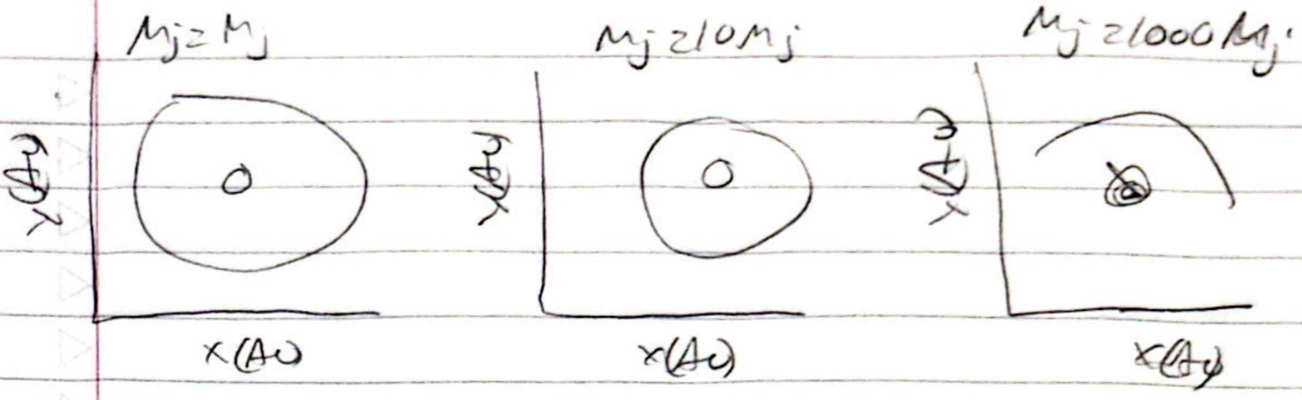
$$r_{Ej}(i) = \sqrt{(x_e(i) - x_j(i))^2 + (y_e(i) - y_j(i))^2}$$

$$v_{ex}(i) = v_{ex}(i-1) - \frac{4\pi^2 x_e(i)}{r_e(i)^3} dt - \frac{4\pi^2 \left(\frac{M_J}{M_S}\right)(x_e(i) - x_j(i))}{r_{Ej}(i)^3} dt$$

$$v_{jx}(i) = v_{jx}(i-1) - \frac{4\pi^2 x_j(i)}{r_j(i)^3} dt - \frac{4\pi^2 \left(\frac{M_E}{M_S}\right)(x_j(i) - x_e(i))}{r_{Ej}(i)^3} dt$$

$$x_e(i) = x_e(i-1) + v_{ex}(i)\, dt$$

$$y_e(i) = y_e(i-1) + v_{ey}(i)\, dt$$




Jupiters effect on Earths orbit is negligable until large cases of $M_j$