1a) To get init condition for circular orbit:

① Set $\boxed{r_0 = 1.0}$

② $a_c = \frac{v_0^2}{r_0} = v_0^2$

③ From previous Lectures / Hws, we know

$$a \simeq \frac{4\pi^2}{r^2} \simeq 4\pi^2 = v_0^2$$

$$\Rightarrow \quad v_0 = \pm(2\pi)$$

choose $\boxed{v_0 = 2\pi}$

□

1b) Reasoning from lecture:

$$\mu r'' = -\frac{dV}{dr} + \frac{L^2}{\mu r^3}$$

$$\frac{dV_{eff}}{dr} = 0 = -F(r) = \mu r''$$

$$r'' = 0$$

$$V(r) = -\frac{\alpha}{r}$$

$$\frac{d\phi}{dt} = \frac{L^2}{\mu r^2}\Big|_{r = r_{min}}$$ const.

$$K = \frac{1}{2}\mu r'^2 + \frac{1}{2} r^2 \phi'^2$$

at $r = r_{min}$ = constant

1c) also from lecture:

$$\frac{dA}{dt} = \frac{L}{2\mu} = \frac{1}{2\mu}\left|\vec{r} \times \vec{p}\right|$$

$$\vec{p} = \mu \vec{v}$$

$$\frac{L}{2\mu} = \frac{1}{2}\left|\vec{r} \times \vec{v}\right|$$

... Set $\mu = 1$ ...

$$L = \left|\vec{r} \times \vec{v}\right|$$

If L constant, then L conserved.
See ipynb.

(d) (e) analysis: see below code cells for each part.

2a) $x_{EJ} = x_E - x_J$ *add x if needed.

$$r_{EJ} = \sqrt{(x_E - x_J)^2 + (y_E - y_J)^2}$$

$$F_{E\text{-}J_x} = \frac{-G \cdot M_J \cdot M_E}{(r_{EJ})^3} x_{E\text{-}J}$$, add to original F

$$a_{E_x} = \frac{-GM_\odot}{|r|^3} x_E - \frac{GM_J}{|r_{EJ}|^3}(x_E - x_J)$$

new

$$= \frac{-4\pi^2 x_E}{|r_E|^3} - 4\pi^2 \left(\frac{M_J}{M_\odot}\right) \frac{(x_E - x_J)}{|r_{EJ}|^3}$$

In general: $$a_E = \frac{-4\pi r_E}{|r_E|^3} - 4\pi^2 \left(\frac{M_J}{M_\odot}\right) \frac{(r_E - r_J)}{|r_{EJ}|^3}$$

Similarly, for the motion of Jupiter:

$$a_J = \frac{-4\pi^2}{|r_J|^3} - 4\pi^2 \left(\frac{M_E}{M_\odot}\right) \frac{(r_J - r_E)}{|r_{JE}|^3}$$

All distances are in AU.

2b) See analysis below 2b) code cells.

2C), scratch, notes.

3D: $F_z = \dfrac{-GM_\odot M_E}{(\sqrt{x^2+y^2+z^2})^3} \cdot z$ ← rabs.

$$\frac{dv_z}{dt} = a = \frac{-GM_G}{|r|^3}$$

$$\frac{dz}{dt} = v_z$$

same for x and y.

⇒ Total of 6 diff eqs. $\begin{pmatrix} x & y & z \\ v_x & v_y & v_z \end{pmatrix}$

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$$M_J = 1.9\,E27\ kg$$

$$F_{E\text{-}J_x} = \frac{-G \cdot M_J \cdot M_E}{(r_{EJ})^3} x_{E\text{-}J}$$

↖ radius between EJ

$$x_{EJ} = x_E - x_J$$

$$r_{EJ} = \sqrt{(x_E - x_J)^2 - (y_E - y_J)^2}$$

a received by Earth from J.

$$\frac{F_{Ex}}{M_E} = \frac{dv_{Ex}}{dt} = \frac{-GM_\odot}{|r|^3} x_E - \frac{GM_J}{|r_{EJ}|^3}(x_E - x_J)$$

Then do y as well.

Note: $GM_\odot = 4\pi^2$, and $a = -\frac{4\pi^2}{|r|^3} \cdot r$

⇓ Change To

$$a_{Ex} = -\frac{4\pi^2 x_E}{|r|^3} - 4\pi^2\left(\frac{M_J}{M_\odot}\right)\frac{(x_E - x_J)}{|r_{EJ}|^3}$$

Sum-up:

$$x_{EJ} = x_E - x_J$$

$$r_{EJ} = \sqrt{(x_E - x_J)^2 - (y_E - y_J)^2}$$

$$F_{E\text{-}J_x} = -\frac{G \cdot M_J \cdot M_E}{(r_{EJ})^3} x_{E\text{-}J}$$, added to original F

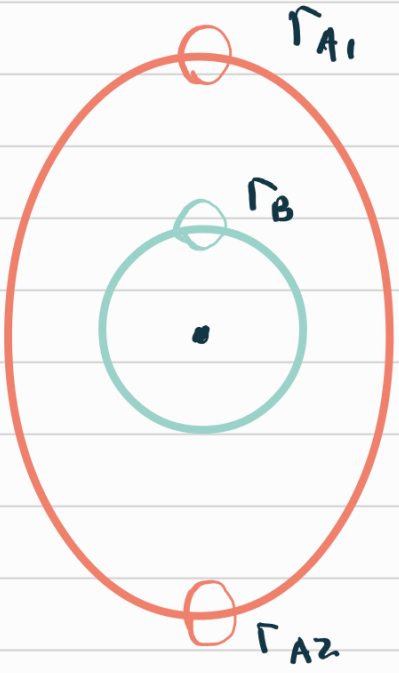
$$a_{Ex} = -\frac{GM_\odot}{|r|^3} x_E - \frac{GM_J}{|r_{EJ}|^3}(x_E - x_J)$$

use ↘

$$= \underbrace{-\frac{4\pi^2 x_E}{|r|^3} - 4\pi^2\left(\frac{M_J}{M_\odot}\right)\frac{(x_E - x_J)}{|r_{EJ}|^3}}_{\text{new}}$$

↓

Relationships:



	Calculated F sign	F Should Be
$r_B - r_{A1} =$	−	+F
$r_B - r_{A2} =$	+	−F
$r_O - r_B = -r_B =$	−	−F

Wait...
If set sign infront as −, then all match up.
Newton's 3rd Law.

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* rabs Planet-Planet. Sun already done.

1	E	7 ☐✓	EJ, E....
2	J	6 ☐✓	JMerc, JV, JMars, JS, JU, JN
3	Merc	5 ☐✓	MercV, MercMars, MercS, MercU, MercN
4	V	4 ☐✓	VMars, VS, VU, VN
5	Mars	3 ☐✓	MarsS, MarsU, MarsN
6	S	2 ☐✓	SU, SN
7	U	1 ☐✓	UN
8	N		

Change:

instead of update with [i+1], do i += 1

then on the bottom t[i+1] = t[i] + DeltaT

becomes t[i] = t[i-1] + DeltaT

- [x] rabs
- [x] rabs update

- [x] acc
- [x] acc update

- [x] Done ?

Problem left: Sign...

See "Relationship" above.

Done. □

Thank you for grading this mess

and have a great day ! :)

Ham