$a_E = 1.496 \times 10^6$ Km

$M_E = 5.9722 \times 10^{24}$ kg

$M_S = 1.98847 \times 10^{30}$ kg

$G = 6.674 \times 10^{-20}$ $Km^3/kg\text{-}s^2$

$\mu = G(M_S + M_E)$

$\mu = 1.3271 \times 10^{11}$ Km

$T = 2\pi \left(\frac{a^3}{\mu}\right)^{1/2}$

Exam 1 topics

- Kepler's
- Dynamics review
- Ref. frames
- two body problem
- elliptical, para, hyperbolic orbits
- num. integration
- three body problem

Exam

3-5 questions, like homework, 75 mins in class

E.S will eq. sheet

Kepler's laws

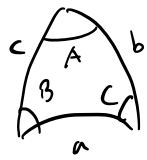
1. elliptical orbits: a, e, relations
2.
3. $T^2 \propto a^3$

Newton's EOM's

2d dynamics, $\frac{GMm}{r^2}$

moving ref. frames $\bar{v}_p$, $\bar{a}_p$,

Spherical triangle sine law



→ Lots of cos laws

Sin → cos w/ (90 − θ) etc. laws!!

Determining time / direction of sunrise
→ steps

Add ECI / topo, heliocentric frames

Two body problem

→ $\frac{d^2\bar{r}}{dt^2} + \frac{\mu}{r^3}\bar{r} = 0$

→ trajectory eqn (w/ h & w/ geometry)

Elliptical

→ speed eqns

Flight path angle

→ cos γ w/ r

→ tan γ w/ θ

γ > 0 moving away

True anomaly, mean motion / anomaly

→ read pizza post

→ $n = \sqrt{\frac{\mu}{a^3}} = \frac{2\pi}{T}$

→ Eccentric anomaly → diagram relating ?

$r\cos\theta = a(\cos E - e)$

and $\tan\frac{\theta}{2} = \sqrt{\frac{1+e}{1-e}}$ ...

Kepler's for ellipse

each orbit type: has diff mean motion rate.

$E - e\sin E = M$

$M = n(t-\tau)$

$n = \sqrt{\frac{\mu}{a^3}}$ → add iterative solve process to eq. sheet!!

Slide 39 overview

Parabolic

- Escape eqn
- parameter $p = \frac{h^2}{\mu}$?
- position on parabolic

$M_p = \sqrt{\frac{\mu}{p^3}}(t-\tau)$

Hyperbolic

- trajectory eqn

$y = \pm\frac{b}{a}x$ → add diagram

add eccentricity number line, energy ↑

$M_H = e \sinh H - H$

Numerical Integration

→ prep equations for num.

2nd order EOM → C.O.V. → 1st order

look @ notes & add to notebook

Circular restricted 3 body problem

$M << m_2 << m_1$

→ HW 4 may help practice 3 body numerical

Lagrange points, orbit maintains shape & stay still relative to each other

Orbital transformations

- orbital elements from ref. frame POV
- MCS ~ ECI

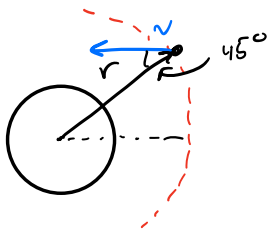
→ not many details of 3d orbits

no MCS formulas

Practice exam

Problem 1

Sat $v = 7.8\ km/s$ @ $r = 4600$ from Earth center.



a) check elliptic / para / hyper

→ check $v_{escape} = \sqrt{\frac{2\mu}{r}} = \sqrt{\frac{2GM}{r}} = 9.1127\ km/s$

$v_{sat} < v_{escape}$ → elliptic

b) get a

$v = \sqrt{\mu\left(\frac{2}{r} - \frac{1}{a}\right)}$ $\quad \frac{v^2}{\mu} = \frac{2}{r} - \frac{1}{a}$ → $\frac{1}{a} = \frac{2}{r} - \frac{v^2}{\mu}$

$$a = \frac{1}{\frac{2}{r} - \frac{v^2}{\mu}} = 17953.61\ km$$

c) get e

$\gamma = -45°$ $\quad \cos(\gamma) = \sqrt{\frac{a^2(1-e^2)}{r(2a-r)}}$