Reading Questions Week #1

to: Prof. Andrew Cumming
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1) What are the constants of motion for two-bodies in orbit around each other?

The constants of motion for two bodies of mass m_1 and m_2 in orbit around each other are the mean motion $n = 2\pi/T$ and the *vis visa* equation constant $C = \frac{1}{2}v^2 - \frac{\mu}{r} = -\frac{\mu}{2a}$, where T = orbital period, v = velocity, $\mu = G(m_1 + m_2)$, r is the distance between the two bodies, and a = the semi-major axis of the elliptic orbit.

2) What is meant by the term "mean motion"?

The term "mean motion" refers to the average angular velocity (i.e., how many radians does m_2 complete around m_1 per second, on average)

3) Sketch an elliptical orbit and label it.

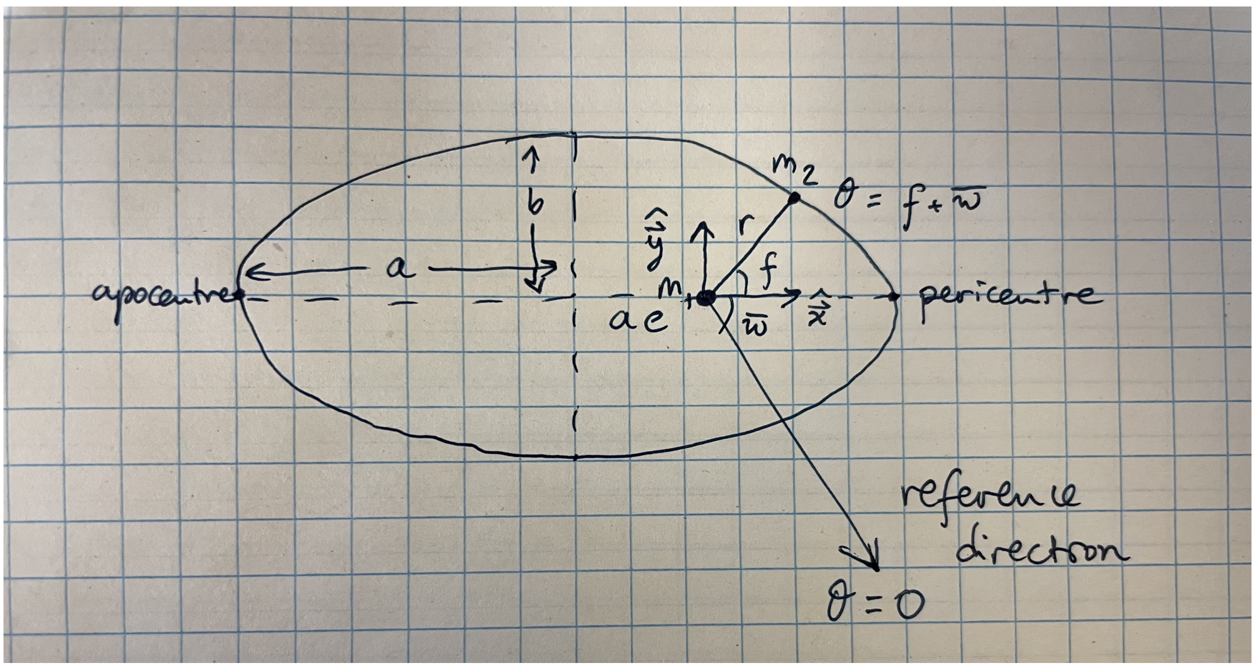

Figure 1: Sketch of an elliptical orbit, with labels for the different associated geometric quantities.

4) What is the difference between mean anomaly, true anomaly, and eccentric anomaly?

The true anomaly is $f = \theta - \bar{\omega}$ (see sketch of the orbit) and is an angular coordinate that refers to the pericentre of the elliptic orbit. The mean anomaly is $M = n(t - \tau)$, where t is time and τ is the time of pericentre passage. The eccentric anomaly E is constructed by considering our elliptical orbit and a circumscribed circle. The eccentric anomaly is then the angle between the major axis of the ellipse and the radius from the center to the intersection point on the circumscribed circle.

5) What is Kepler's equation?

Kepler's equation is a relation between the mean anomaly and the eccentric anomaly: $M = E - e \sin E$.

6) If you want to set up an orbit with semi-major axis a and eccentricity e, how do you choose the initial location and velocity?

You can choose any starting location you want r. Then, the corresponding velocity can be calculated with the *vis visa* equation: $v^2 = \mu(\frac{2}{r} - \frac{1}{a})$.

7) Explain why, even though the Moon is tidally-locked, it appears to wobble (librate) to an observer on Earth.

The Moon wobbles to an observer on Earth because its orbit is not perfectly circular, and its axis is tilted.

8) Underneath each of equations (2.157) and (2.162), the text gives a brief physical explanation. Explain how the physical explanation gives rise to the equation in each case.

Equation 2.157 and 2.162 read:

$$\frac{dI}{dt} = \frac{n\bar{N}\cos(\omega + f)}{h} \tag{1}$$

and:

$$\frac{d\Omega}{dt} = \frac{n\bar{N}\sin(\omega + f)}{h \sin I} \tag{2}$$

where I is the inclination of the orbit with respect to a reference plane, $\bar{N}$ is the magnitude of the normal component of the force, Ω is the longitude of ascending node (the ascending node is the point in both planes where the orbit crosses the reference plane moving from below to above the plane, such that the ascending node is the angle between the reference line and the radius vector to the ascending node), and ω is the argument of pericentre, which is the angle between this same radius vector and the pericentre.