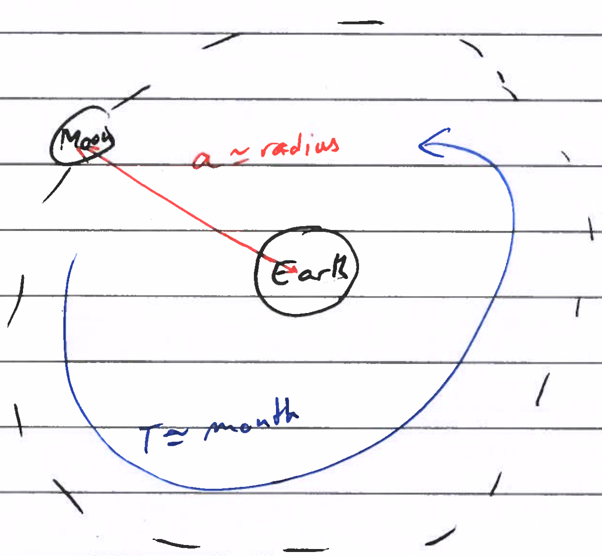
Monday, February 9, 2026

Example: Newton's version of Kepler's 3rd law for determining planetary mass.

If we assume that $M_{Moon} \ll M_{Earth}$, then we can measure M_{Earth} with the Moon's orbit.

Moon's orbital parameters: $a = 384399$ km

$\simeq 3.84 \times 10^{8}$ m



$T = 27.3$ days (Moon's orbital period)

$= 27.3 \times 24 \times 60 \times 60$

$= 2358720$ s

$\simeq 2.36 \times 10^{6}$ s

Newton's version of Kepler's 3rd Law:

$$T^2 = \frac{4\pi^2}{G\,(\underbrace{M_{Earth} + M_{Moon}}_{\simeq M_{Earth}})}\, a^3 \Rightarrow T^2 \simeq \frac{4\pi^2}{G\, M_{Earth}}\, a^3$$

$$\Rightarrow M_{Earth} \simeq \frac{4\pi^2}{G} \frac{a^3}{T^2} = \frac{4(3.1415926)^2}{(6.6743 \times 10^{-11})} \frac{(3.84 \times 10^{8})^3}{(2.36 \times 10^{6})^2}$$

$$\simeq 6.01 \times 10^{24} \text{ kg}$$

$$\Rightarrow \boxed{M_{Earth} \simeq 6.01 \times 10^{24}\ kg}$$

Real Mass of the Earth: $M_{Earth} = 5.97 \times 10^{24}\ kg$