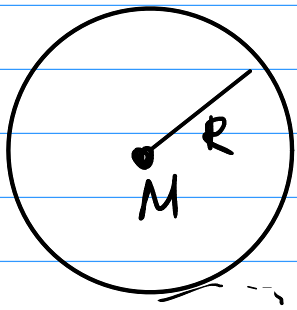
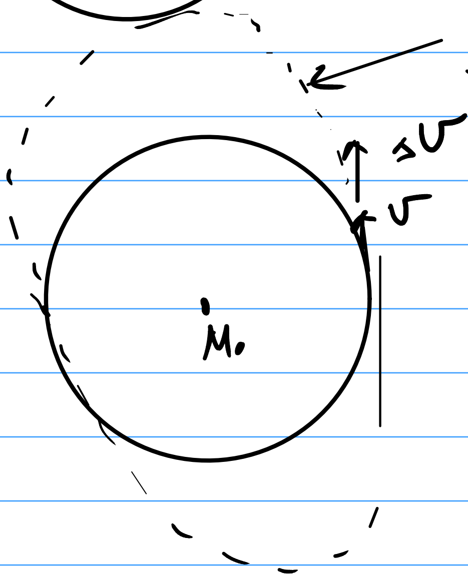
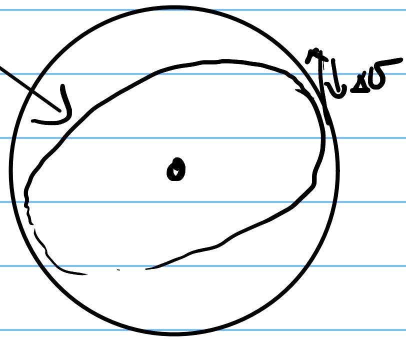
3rd Kepler's law

$R^3 \sim T^2$



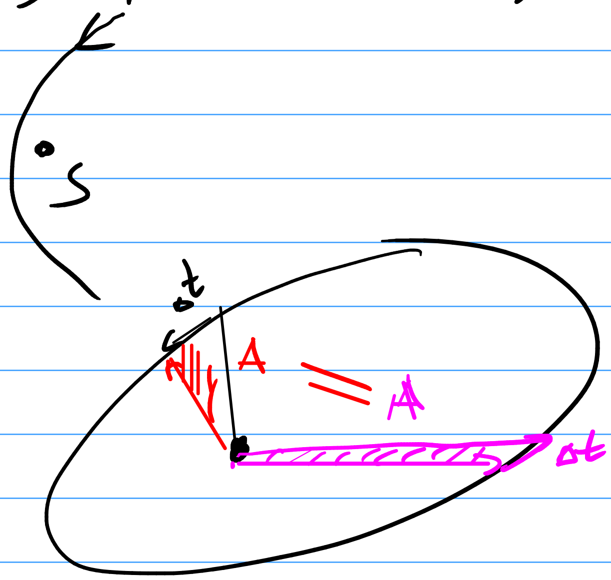
Ellipse

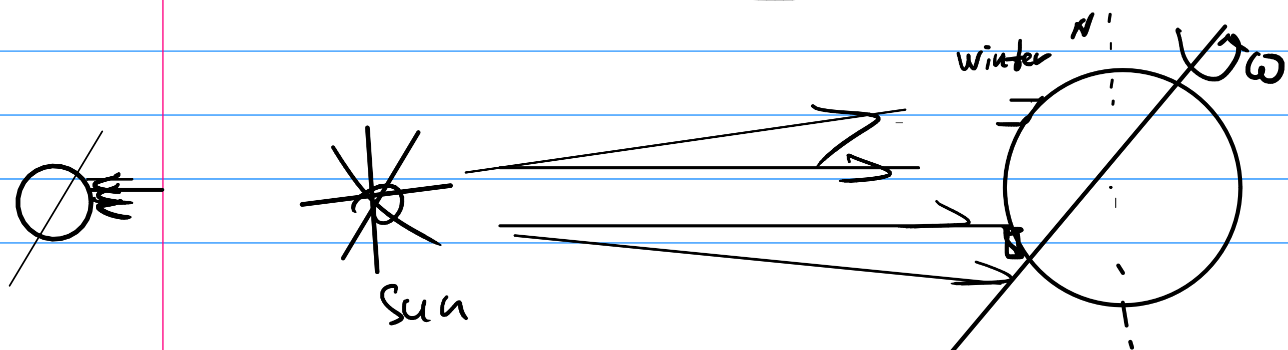




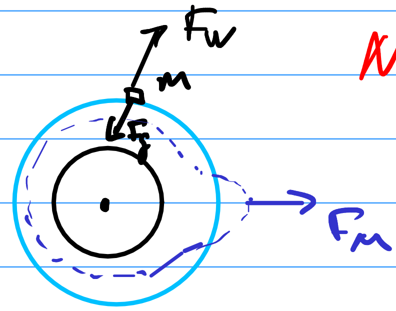
1st Everything (Gravitationaly bound) moves along ellipse

not bounded orbits
described by parabolic and hyperbolic





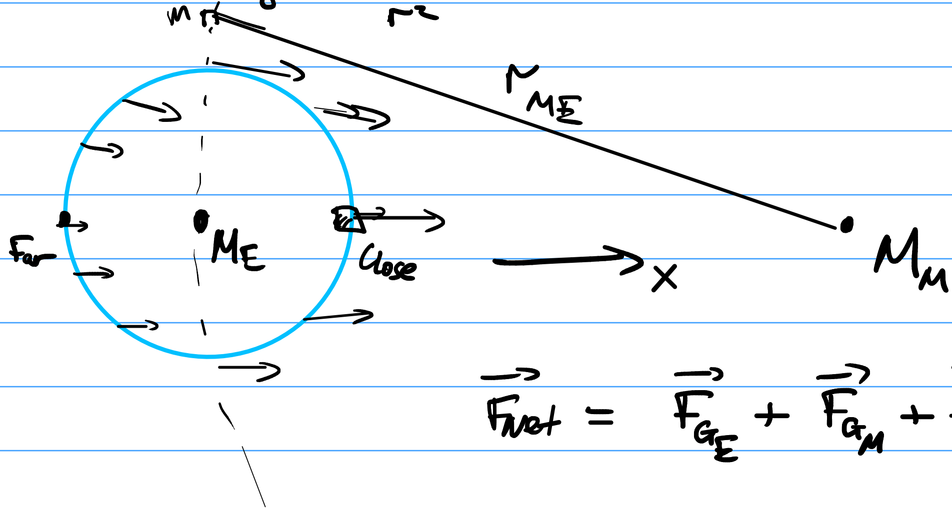
Tides



Naive and wrong

• M

$$F_g = \frac{G M_m \cdot m}{r^2}$$



$$\vec{F}_{net} = \vec{F}_{G_E} + \vec{F}_{G_M} + \vec{F}_{Water}$$

X:
$$F_{net\ close} = -\frac{G \cdot M_E \cdot m}{R_E^2} + \frac{G M_M m}{(r_{ME} - R_E)^2} + F_{W_{close}}$$

$$F_{net\ Far} = \frac{G M_E m}{R_E^2} + \frac{G M_M m}{(r_{ME} + R_E)^2} + F_{W_{far}}$$

$$F_M = \frac{G M_M m}{(r_{ME} \mp R_E)^2} = \frac{G M_M m}{r_{ME}^2 \left(1 \mp \frac{R_E}{r_{ME}}\right)^2} \overset{\frac{R_E}{r_{ME}} \ll 1}{\approx} \frac{G M_M m}{r_{ME}^2}\left(1 \pm \frac{R_E}{r_{ME}} 2\right)$$

$$\cancel{F_{net\ \substack{close \\ Far}}} \to 0 = \mp \cancel{\frac{G M_E m}{R_E^2}} + \cancel{\frac{G M_M m}{r_{ME}^2}} + (\pm) \frac{G M_M \cdot m}{r_{ME}^2} \frac{2 R_E}{r_{ME}} + \overset{F_{eq} + \Delta F_W}{\cancel{F_{W_{\substack{close \\ far}}}}}$$

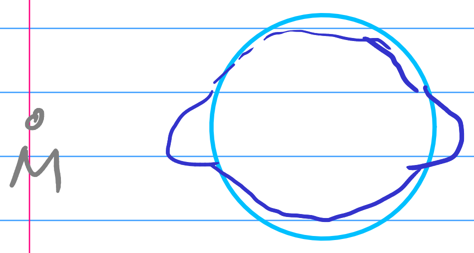
$$0 = \pm \frac{G M_M m}{r_{ME}^2} \frac{2 R_E}{r_{ME}} + \Delta F_{W\ \substack{Close \\ Far}}$$

$$\left| \Delta F_W \right| = \frac{G M_M m}{r_{ME}^2} \frac{2 R_E}{r_{ME}} \sim h_{tide\ Moon}$$

$$h_{sun} \approx \frac{G M_s m}{r_{SE}^2} \cdot \frac{2R_E}{r_{SE}}$$

M_s

Sun



M

M

M_s

M_M

$$h \sim \underbrace{2 G m R_E}_{\text{common}} \cdot \frac{M}{r^3}$$

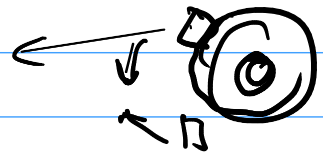
r_{SE}

r_{SM}

$$\frac{h_s}{h_M} = \frac{M_s}{M_E}\frac{r_{EM}^3}{r_{ES}^3} = 0.5$$

Surface lock

M_E



E