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Gravitation / Electrostatics Solutions

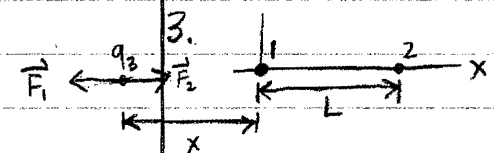
1. $g = \frac{GM}{R^2}$ $\quad g_{new} = \frac{GM_e}{(r_e/6)^2} = \frac{36GM_e}{r_e^2} = 36(9.8\,m/s^2) = \boxed{352.8\,m/s^2}$

2. $|F_g| = \frac{G m_{earth} m_{moon}}{d^2} = \frac{(6.67\cdot10^{-11}N\cdot m^2/kg^2)(5.97\cdot10^{24}kg)(7.35\cdot10^{22}kg)}{d^2}$

$|F_e| = \frac{k|q_{earth}||q_{moon}|}{d^2} = \frac{(8.99\cdot10^9 N\cdot m^2/C^2)(10C)(10C)}{d^2}$

$\frac{F_g}{F_e} = \boxed{3.26\cdot10^{25}}$ This indicates that the gravitational force is much stronger, and the electrostatic force is negligible.

3.



$\Sigma F_x = ma_x$

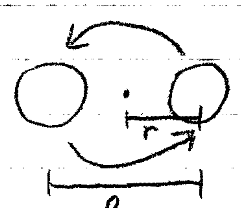
$F_2 - F_1 = 0, \; F_1 = F_2$

$\frac{k(1.0)q}{x^2} = \frac{k(3.2)q}{(17+x)^2}$

$3.2x^2 = 289 + 34x + x^2, \; 2.2x^2 - 34x - 289 = 0$

$x = \boxed{21.55\text{ cm to the left of particle 1}}$

4. NOTE: You can't use Kepler's Third Law directly in this problem since the two stars have equal mass.



R: center-to-center separation
r: orbital radius.
Center of mass is at the middle, so $r = \frac{R}{2}$.

$m\frac{v^2}{r} = \frac{GmM}{R^2}, \quad \cancel{m}\frac{\left(\frac{2\pi r}{T}\right)^2}{r} = \frac{G\cancel{m}M}{R^2}, \quad \frac{\frac{4\pi^2 r^2}{T^2}}{r} = \frac{GM}{R^2}, \quad \frac{4\pi^2 r}{T^2} = \frac{GM}{R^2}$

$r = \frac{R}{2}$, so $\frac{2\pi^2 R}{T^2} = \frac{GM}{R^2}, \quad 2\pi^2R^3 = GMT^2, \quad \frac{2\pi^2}{GM}R^3 = T^2$

$T = \sqrt{\frac{2\pi^2R^3}{GM}} = \sqrt{\frac{2\pi^2(1.6\cdot10^8\,km)^3\left(\frac{1000\,m}{1\,km}\right)^3}{(6.67\cdot10^{-11}N\cdot m^2/kg^2)(1.16\cdot10^{30}kg)}} = 3.233\cdot10^7 s$

$3.233\cdot10^7 \cancel{s}\left(\frac{1\,hr}{3600\,\cancel{s}}\right)\left(\frac{1\,day}{24\,hr}\right)\left(\frac{1\,yr}{365\,days}\right) = \boxed{1.03\text{ yrs}}$