Problem 1. Which pulls harder on the Moon: Earth or the Sun?

Table 13.1 Solar system data (in SI units and relative to Earth)

	Mass		Equatorial radius		semimajor axis		Orbit* eccentricity	period	
	(kg)	(m_E)	(m)	(R_E)	(m)	(a_E)		(s)	(years)
Sun	2.0×10^{30}	3.3×10^{5}	7×10^{8}	110	-	-	-	-	-
Mercury	3.30×10^{23}	0.06	2.440×10^{6}	0.38	5.79×10^{10}	0.39	0.206	7.60×10^{6}	0.24
Venus	4.87×10^{24}	0.81	6.052×10^{6}	0.95	1.082×10^{11}	0.72	0.007	1.94×10^{7}	0.62
Earth	5.97×10^{24}	1	6.378×10^{6}	1	1.496×10^{11}	1	0.017	3.16×10^{7}	1
Mars	6.42×10^{23}	0.11	3.396×10^{6}	0.53	2.279×10^{11}	1.52	0.09	5.94×10^{7}	1.88
Jupiter	1.90×10^{27}	318	7.149×10^{7}	11.2	7.783×10^{11}	5.20	0.05	3.74×10^{8}	11.86
Saturn	5.68×10^{26}	95.2	6.027×10^{7}	9.45	1.427×10^{12}	9.54	0.05	9.29×10^{8}	29.45
Uranus	8.68×10^{25}	14.5	2.556×10^{7}	4.01	2.871×10^{12}	19.2	0.05	2.65×10^{9}	84.02
Neptune	1.02×10^{26}	17.1	2.476×10^{7}	3.88	4.498×10^{12}	30.1	0.01	5.20×10^{9}	164.8
Pluto	1.31×10^{22}	0.002	1.151×10^{6}	0.18	5.906×10^{12}	39.5	0.25	7.82×10^{9}	247.9
Moon	7.3×10^{22}	0.012	1.737×10^{6}	0.27	3.84×10^{8}	0.0026	0.055	2.36×10^{6}	0.075

*The elliptical orbits of the planets and the Moon are specified by their *semimajor axis a* (half the major axis) and eccentricity *e*; see Figure 13.7. With the exception of Mercury and Pluto, the eccentricity is small and so the orbits are close to being circular.

$$F^G_{EM} = G\frac{m_E m_M}{r^2_{EM}} = \left(6.67\times10^{-11}\ Nm^2/kg^2\right)\frac{(5.97\times10^{24}\ kg)(7.3\times10^{22}\ kg)}{(3.84\times108\ m)^2}$$

$$= 1,97\times10^{20}\ N$$

$$F^G_{SM} = G\frac{m_S m_M}{r^2_{SM}} = \left(6.67\times10^{-11}\ \frac{Nm^2}{Kg^2}\right)\frac{(2\times10^{30}\ kg)(7.3\times10^{22}\ kg)}{(1.496\times10^{11})^2}$$

$$= 4,35\times10^{20}\ N$$

$$\therefore F^G_{SM} > F^G_{EM}$$

Problem 2. Mars' period (its "year") was noted by Kepler to be about 687 days (Earth days), which is (687 d/365 d) = 1.88 yr. Determine the distance of Mars from the Sun using the Earth as a reference using Kepler's third law ($T^2 \propto r^3$).

M: Mars, E: Earth, S: Sun

$T_M^2 = K r_{MS}^3$ for some constant K

$T_E^2 = K r_{ES}^3$

$$\Rightarrow \frac{r_{MS}}{r_{ES}} = \left(\frac{T_M}{T_E}\right)^{2/3} = (1.88)^{2/3} = 1,52$$

$$\Rightarrow r_{MS} = 1,52\ r_{ES}$$

$$= 1.52\ (1.496\times10^{11}\ m) = 2,27\times10^{11}\ m$$