Answer on Question 55489, Physics, Mechanics | Kinematics | Dynamics

Question:

a) What is the magnitude of the force of gravity between Earth and Jupiter (take mass of the Earth $M_E = 6.0 \cdot 10^{24} kg$, mass of Jupiter $M_J = 1.9 \cdot 10^{27} kg$, and the distance between their centres $R_{EJ} = 5.89 \cdot 10^{8} km$)?

b) At what point between Earth and Jupiter is the net force of gravity on a body by both Earth and Jupiter exactly zero?

Solution:

a) By the Newton's law of universal gravitation, the magnitude of the force of gravity between Earth and Jupiter is:

$$F_{EJ} = G\frac{M_E M_J}{R_{EJ}^2} = 6.67 \cdot 10^{-11}\frac{N \cdot m^2}{kg^2} \cdot \frac{6.0 \cdot 10^{24} kg \cdot 1.9 \cdot 10^{27} kg}{(5.89 \cdot 10^{11} m)^2} = 2.19 \cdot 10^{18} N.$$

b) Let r be the distance from the center of the Jupiter to the point where the net force of gravity on a body is equal to zero and let R_{EJ} is the distance between the centers of the Earth and Jupiter. Then the distance from the center of the Earth to the point of zero net force is $R_{EJ} - r$. By the Newton's law of universal gravitation, the force acting from the Jupiter on a body of mass m at this point will be:

$$F = G\frac{M_J m}{r^2}.$$

The force acting from the Earth on a body of mass m at this point will be (we use the relationship $M_E = \frac{1}{317} M_J$):

$$F = G\frac{\frac{1}{317} M_J m}{(R_{EJ} - r)^2}.$$

Thus, we equate this expressions:

$$\frac{1}{r^2} = \frac{\frac{1}{317}}{(R_{EJ} - r)^2},$$

$$\sqrt{317}\left(R_{EJ} - r\right) = r,$$

$$\sqrt{317}R_{EJ} = r\left(1+\sqrt{317}\right),$$

$$r = \frac{\sqrt{317}R_{EJ}}{\left(1+\sqrt{317}\right)} = \frac{18}{19}R_{EJ} = \frac{18}{19}\cdot 5.89\cdot 10^{11}m = 5.58\cdot 10^{11}m.$$

Answer:

a) $F_{EJ} = 2.19\cdot 10^{18}N$.

b) $r = 5.58\cdot 10^{11}m$.