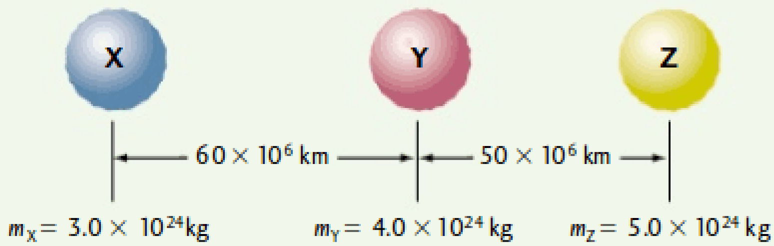
Gravitation
Practice Problems

Apply Newton's Law of Universal Gravitation to solve the following two problems.

56. Three planets, *X*, *Y*, and *Z*, are situated as shown in Figure 1.68. What is the net gravitational force on planet *Z*?

Fig.1.68

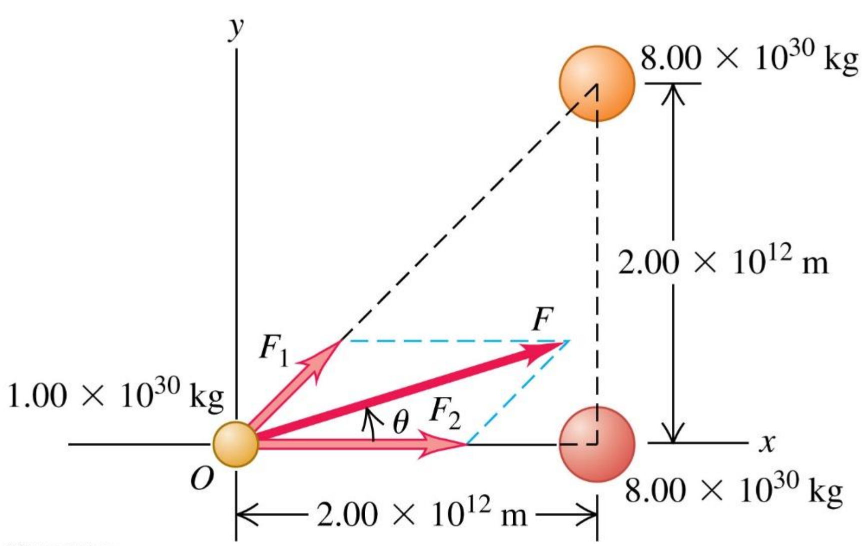


57. A 100-kg astronaut is in a spacecraft 300 km above Earth's surface. What is the force of gravity on him at this location?

Apply Newton's Law of Universal Gravitation to solve the following problem.

Example 13.3 Superposition of gravitational forces

Many stars belong to *systems* of two or more stars held together by their mutual gravitational attraction. Figure 13.5 shows a three-star system at an instant when the stars are at the vertices of a 45° right triangle. Find the total gravitational force exerted on the small star by the two large ones.



Answers:
56.
6.16 x 10^{17} N

hmm, what about sumation of the forces on planet z both planet x and planet y have a gravitational force acting in accordance with z. this should be correct because the question asks for the NET gravitational force just one would be a component of the net force. You would need to apply the law for the first distance added to the law for the combined distances

F_{Net}= [(G x (m_1xm_2)/r_1^2] + [G x (m_1xm_2/(r_1+r_2)^2]

The gravitational force does not depend upon which bodies are closest. Every mass interacts with every other mas according to the inverse square law. So for question 56, sum the forces due to both X and Y according to their respective distances.

57.
894 N

For question 57, consider what the R distance represents in the gravitational force equation, then re-read the question statement.

The force depends upon the astronaut's distance from the Earth's center!

If it's not the radial distance, then calculate the radial distance! Height above Earth's surface is not the same as the distance from the Earth's center!

Look up a value for the Earth's radius. That's the distance from the Earth's center to the Earth's surface. In the problem you're given the distance of the astronaut from the Earth's surface. Do the addition.

Example 13.3

SOLUTION

IDENTIFY, SET UP, and EXECUTE: We use the principle of superposition: The total force $\vec{F}$ on the small star is the vector sum of the forces $\vec{F}_1$ and $\vec{F}_2$ due to each large star, as Fig. 13.5 shows. We assume that the stars are spheres as in Fig. 13.2. We first calculate the magnitudes F_1 and F_2 using Eq. (13.1) and then compute the vector sum using components:

$$F_1 = \frac{\left[\begin{array}{c}(6.67 \times 10^{-11}\,\mathrm{N\cdot m^2/kg^2})\\ \times (8.00 \times 10^{30}\,\mathrm{kg})(1.00 \times 10^{30}\,\mathrm{kg})\end{array}\right]}{(2.00 \times 10^{12}\,\mathrm{m})^2 + (2.00 \times 10^{12}\,\mathrm{m})^2}$$

$$= 6.67 \times 10^{25}\,\mathrm{N}$$

$$F_2 = \frac{\left[\begin{array}{c}(6.67 \times 10^{-11}\,\mathrm{N\cdot m^2/kg^2})\\ \times (8.00 \times 10^{30}\,\mathrm{kg})(1.00 \times 10^{30}\,\mathrm{kg})\end{array}\right]}{(2.00 \times 10^{12}\,\mathrm{m})^2}$$

$$= 1.33 \times 10^{26}\,\mathrm{N}$$

The x- and y-components of these forces are

$$F_{1x} = (6.67 \times 10^{25}\,\mathrm{N})(\cos 45^\circ) = 4.72 \times 10^{25}\,\mathrm{N}$$
$$F_{1y} = (6.67 \times 10^{25}\,\mathrm{N})(\sin 45^\circ) = 4.72 \times 10^{25}\,\mathrm{N}$$
$$F_{2x} = 1.33 \times 10^{26}\,\mathrm{N}$$
$$F_{2y} = 0$$

The components of the total force $\vec{F}$ on the small star are

$$F_x = F_{1x} + F_{2x} = 1.81 \times 10^{26}\ \text{N}$$
$$F_y = F_{1y} + F_{2y} = 4.72 \times 10^{25}\ \text{N}$$

The magnitude of $\vec{F}$ and its angle θ (see Fig. 13.5) are

$$F = \sqrt{F_x^2 + F_y^2} = \sqrt{(1.81 \times 10^{26}\ \text{N})^2 + (4.72 \times 10^{25}\ \text{N})^2}$$
$$= 1.87 \times 10^{26}\ \text{N}$$
$$\theta = \arctan\frac{F_y}{F_x} = \arctan\frac{4.72 \times 10^{25}\ \text{N}}{1.81 \times 10^{26}\ \text{N}} = 14.6^\circ$$

EVALUATE: While the force magnitude F is tremendous, the magnitude of the resulting acceleration is not: $a = F/m = (1.87 \times 10^{26}\ \text{N})/(1.00 \times 10^{30}\ \text{kg}) = 1.87 \times 10^{-4}\ \text{m/s}^2$. Furthermore, the force $\vec{F}$ is *not* directed toward the center of mass of the two large stars.