Circular Motion and Gravitation

ADDITIONAL PRACTICE C

Givens | *Solutions*

1. $r = 6.3$ km

$F_g = 2.5 \times 10^{-2}$ N

$m_1 = 3.0$ kg

$G = 6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}$

$$m_2 = \frac{F_g r^2}{G m_1} = \frac{(2.5 \times 10^{-2}\ \text{N})(6.3 \times 10^3\ \text{m})^2}{\left(6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)(3.0\ \text{kg})}$$

$$m_2 = \boxed{5.0 \times 10^{15}\ \text{kg}}$$

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2. $m_1 = 3.08 \times 10^4$ kg

$r = 1.27 \times 10^7$ m

$F_g = 2.88 \times 10^{-16}$ N

$G = 6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}$

$$m_2 = \frac{F_g r^2}{G m_1} = \frac{(2.88 \times 10^{-16}\ \text{N})(1.27 \times 10^7\ \text{m})^2}{\left(6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)(3.08 \times 10^4\ \text{kg})}$$

$$m_2 = \boxed{2.26 \times 10^4\ \text{kg}}$$

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3. $m_1 = 5.81 \times 10^4$ kg

$r = 25.0$ m

$F_g = 5.00 \times 10^{-7}$ N

$G = 6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}$

$$m_2 = \frac{F_g r^2}{G m_1} = \frac{(5.00 \times 10^{-7}\ \text{N})(25.0\ \text{m})^2}{\left(6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)(5.81 \times 10^4\ \text{kg})}$$

$$m_2 = \boxed{80.6\ \text{kg}}$$

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4. $m_1 = 621$ g

$m_2 = 65.0$ kg

$F_g = 1.0 \times 10^{-12}$ N

$G = 6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}$

$$r = \sqrt{\frac{G m_1 m_2}{F_g}}$$

$$r = \sqrt{\frac{(6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2)(0.621\ \text{kg})(65.0\ \text{kg})}{1.0 \times 10^{-12}\ \text{N}}} = \boxed{52\ \text{m}}$$

Givens	*Solutions*
5. $m_1 = m_2 = 1.0 \times 10^8$ kg $F_g = 1.0 \times 10^{-3}$ N $G = 6.673 \times 10^{-11} \frac{N{\bullet}m^2}{kg^2}$	$r = \sqrt{\frac{Gm_1m_2}{F_g}}$ $r = \sqrt{\frac{(6.673 \times 10^{-11}\ N{\bullet}m^2/kg^2)(1.0 \times 10^8\ kg)^2}{1.0 \times 10^{-3}\ N}}$ $r = 2.6 \times 10^4\ m = \boxed{26\ km}$
6. $m_s = 25 \times 10^9$ kg $m_1 = m_2 = \frac{1}{2}m_s$ $r = 1.0 \times 10^3$ km $G = 6.673 \times 10^{-11} \frac{N{\bullet}m^2}{kg^2}$	$F_g = \frac{Gm_1m_2}{r^2} = \frac{\left(6.673 \times 10^{-11}\ \frac{N{\bullet}m^2}{kg^2}\right)\left[\frac{1}{2}(25 \times 10^9\ kg)\right]^2}{(1.0 \times 10^6\ m)^2} = \boxed{1.0 \times 10^{-2}\ N}$
7. $m_1 = 318m_E$ $m_2 = 50.0$ kg $V_J = 1323V_E$ $m_E = 5.98 \times 10^{24}$ kg $r_E = 6.37 \times 10^6$ m $G = 6.673 \times 10^{-11} \frac{N{\bullet}m^2}{kg^2}$	If $V_J = 1323\ V_E$, then $r_J = \sqrt[3]{1323}\, r_E$. $F_g = \frac{Gm_1m_2}{{r_J}^2} = \frac{(6.673 \times 10^{-11}\ N{\bullet}m^2/kg^2)(318)(5.98 \times 10^{24}\ kg)(50.0\ kg)}{[(\sqrt[3]{1323})(6.37 \times 10^6\ m)]^2}$ $F_g = \boxed{1.30 \times 10^3\ N}$

Problem C

GRAVITATIONAL FORCE

PROBLEM

The sun has a mass of 2.0×10^{30} kg and a radius of 7.0×10^{5} km. What mass must be located at the sun's surface for a gravitational force of 470 N to exist between the mass and the sun?

SOLUTION

Given: $m_1 = 2.0 \times 10^{30}$ kg

$r = 7.0 \times 10^{5}$ km $= 7.0 \times 10^{8}$ m

$G = 6.673 \times 10^{-11}$ N•m^2/kg^2

$F_g = 470$ N

Unknown: $m_2 = ?$

Use Newton's universal law of gravitation, and rearrange it to solve for the second mass.

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$m_2 = \frac{F_g r^2}{G m_1} = \frac{(470\ \text{N})(7.0 \times 10^{8}\ \text{m})^2}{\left(6.673 \times 10^{-11}\ \frac{\text{N} \bullet \text{m}^2}{\text{kg}^2}\right)(2.0 \times 10^{30}\ \text{kg})}$$

$$m_2 = 1.7\ \text{kg}$$

ADDITIONAL PRACTICE

1. Deimos, a satellite of Mars, has an average radius of 6.3 km. If the gravitational force between Deimos and a 3.0 kg rock at its surface is 2.5×10^{-2} N what is the mass of Deimos?
2. A 3.08×10^{4} kg meteorite is on exhibit in New York City. Suppose this meteorite and another meteorite are separated by 1.27×10^{7} m (a distance equal to Earth's average diameter). If the gravitational force between them is 2.88×10^{-16} N, what is the mass of the second meteorite?
3. In 1989, a cake with a mass of 5.81×10^{4} kg was baked in Alabama. Suppose a cook stood 25.0 m from the cake. The gravitational force exerted between the cook and the cake was 5.0×10^{-7} N. What was the cook's mass?
4. The largest diamond ever found has a mass of 621 g. If the force of gravitational attraction between this diamond and a person with a mass of 65.0 kg is 1.0×10^{-12} N, what is the distance between them?

5. The passenger liners *Carnival Destiny* and *Grand Princess*, built recently, have a mass of about 1.0×10^8 kg each. How far apart must these two ships be to exert a gravitational attraction of 1.0×10^{-3} N on each other?
6. In 1874, a swarm of locusts descended on Nebraska. The swarm's mass was estimated to be 25×10^9 kg. If this swarm were split in half and the halves separated by 1.0×10^3 km, what would the magnitude of the gravitational force between the halves be?
7. Jupiter, the largest planet in the solar system, has a mass 318 times that of Earth and a volume that is 1323 times greater than Earth's. Calculate the magnitude of the gravitational force exerted on a 50.0 kg mass on Jupiter's surface.