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CHAPTER 7.5: GRAVITATIONAL FORCE

NEWTON'S LAW OF UNIVERSAL GRAVITATION

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

$$\text{gravitational force} = \text{constant} \times \frac{\text{mass 1} \times \text{mass 2}}{(\text{distance between masses})^2}$$

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

PRACTICE C

Gravitational Force

1. What must be the distance between two 0.800 kg balls if the magnitude of the gravitational force between them is equal to that in Sample Problem C?
2. Mars has a mass of about 6.4×10^{23} kg, and its moon Phobos has a mass of about 9.6×10^{15} kg. If the magnitude of the gravitational force between the two bodies is 4.6×10^{15} N, how far apart are Mars and Phobos?
3. Find the magnitude of the gravitational force a 66.5 kg person would experience while standing on the surface of each of the following planets:

Planet	Mass	Radius
a. Earth	5.97×10^{24} kg	6.38×10^{6} m
b. Mars	6.42×10^{23} kg	3.40×10^{6} m
c. Pluto	1.25×10^{22} kg	1.20×10^{6} m

ANSWERS

Practice C

1. 0.692 m
2. 9.4×10^{6} m
3. a. 651 N
   b. 246 N
   c. 38.5 N

4. A planet has two moons with identical mass. Moon 1 is in a circular orbit of radius *r*. Moon 2 is in a circular orbit of radius 2*r*. The magnitude of the gravitational force exerted by the planet on Moon 2 is (a) four times as large (b) twice as large (c) the same (d) half as large (*e*) one-fourth as large as the gravitational force exerted by the planet on Moon 1. Explain.

CQ:

6. At night, you are farther away from the Sun than during the day. What's more, the force exerted by the Sun on you is downward into Earth at night, and upward into the sky during the day. If you had a sensitive enough bathroom scale, would you appear to weigh more at night than during the day?

8. Why does an astronaut in a spacecraft orbiting Earth experience a feeling of weightlessness?

TABLE 7.3

Useful Planetary Data

Body	Mass (kg)	Mean Radius (m)	Period (s)	Mean Distance from Sun (m)	$\frac{T^2}{r^3}\,10^{-19}\left(\frac{s^2}{m^3}\right)$
Mercury	3.18×10^{23}	2.43×10^{6}	7.60×10^{6}	5.79×10^{10}	2.97
Venus	4.88×10^{24}	6.06×10^{6}	1.94×10^{7}	1.08×10^{11}	2.99
Earth	5.98×10^{24}	6.38×10^{6}	3.156×10^{7}	1.496×10^{11}	2.97
Mars	6.42×10^{23}	3.37×10^{6}	5.94×10^{7}	2.28×10^{11}	2.98
Jupiter	1.90×10^{27}	6.99×10^{7}	3.74×10^{8}	7.78×10^{11}	2.97
Saturn	5.68×10^{26}	5.85×10^{7}	9.35×10^{8}	1.43×10^{12}	2.99
Uranus	8.68×10^{25}	2.33×10^{7}	2.64×10^{9}	2.87×10^{12}	2.95
Neptune	1.03×10^{26}	2.21×10^{7}	5.22×10^{9}	4.50×10^{12}	2.99
Pluto	1.27×10^{23}	1.14×10^{6}	7.82×10^{9}	5.91×10^{12}	2.96
Moon	7.36×10^{22}	1.74×10^{6}	—	—	—
Sun	1.991×10^{30}	6.96×10^{8}	—	—	—

More Problems:

29. The average distance separating Earth and the Moon is 384,000 km. Use the data in Table 7.3 to find the net gravitational force exerted by Earth and the Moon on a 3.00 x 10^4-kg spaceship located halfway between them.

30. During a solar eclipse, the Moon, Earth, and Sun all lie on the same line, with the Moon between Earth and the Sun.
(a) What force is exerted by the Sun on the Moon?
(b) What force is exerted by Earth on the Moon?
(c) What force is exerted by the Sun on Earth? (See Table 7.3 and Problem 29.)

32. A coordinate system (in meters) is constructed on the surface of a pool table, and three objects are placed on the table as follows: a 2.0-kg object at the origin of the coordinate system, a 3.0-kg object at (0, 2.0), and a 4.0-kg object at (4.0, 0). Find the resultant gravitational force exerted by the other two objects on the object at the origin.

Answers:

29) The resultant force is $(325\text{ N} - 4.00\text{ N}) = \boxed{321\text{ N directed toward Earth}}$.

30) $F_{MS} = \boxed{4.39 \times 10^{20}\text{ N toward the Sun}}$

32) $r = \boxed{2.59 \times 10^{8}\text{ m from center of the Earth}}$