(Mass of Earth) $m_E = 5.9737 \times 10^{24}$ kg (Mean Radius of Earth) $r_E = 6\ 371\ 000$ m
(Gravitational Constant) $G = 6.61 * 10^{-11}$ N * m^2 / kg^2
(Mass of Sun) $m_s = 1.99 * 10^{30}$ kg

Name_____Period_____Date_____

Universal Gravitation and Circular Motion

1. A communications satellite with a mass of 250 kg is in a circular orbit about the Earth. The radius of the orbit is 35,000 km as measured from the center of the Earth. Calculate:
   (a) the weight of the satellite on the surface of the Earth.
   (b) the gravitational force exerted on the satellite by the Earth when it is in orbit.

2. In one hand you hold a .12-kg apple, in the other hand a .20-kg orange. The apple and orange are separated by .75 m. What is the magnitude of the force of gravity that
   (a) the orange exerts on the apple?
   (b) the apple exerts on the orange?

3. Titan is the largest moon of Saturn, and the only moon in the solar system known to have a substantial atmosphere. Find the acceleration of gravity on Titan's surface, given that its mass is 1.35 x 10^{23} kg and its radius is 2570 km.

1a. 2500 N **b.** 81 N **2a.** $2.8 * 10^{-12}$ N **2b.** $2.8 * 10^{-12}$ N **3.** 1.36 m/s^2 **4.** $7.7 * 10^6$ m
5. $1.90 * 10^{27}$ kg **6**. 20 h **7.** $1.44 * 10^6$ m **8a.** $9.9 * 10^{30}$ kg **8b.** 5.0 times
9a. 7757.52 m/s 9b. 5362.66 s (1.49 h) **10.** 7765 m/s **11.** 8.57 m/s **12.** 3.1 m/s
13a. 1.14 N **13b.** .154N **14a.** 0.16 N **14b.** 6.73 N

(Mass of Earth) $m_E = 5.9737 \times 10^{24}$ kg (Mean Radius of Earth) $r_E = 6\ 371\ 000$ m
(Gravitational Constant) $G = 6.61 * 10^{-11}$ N * m^2 / kg^2
(Mass of Sun) $m_s = 1.99 * 10^{30}$ kg

4. Find the distance from the center of the Earth at which a 3.0-kg object has a weight of 20.0 N.

5. The largest moon in the solar system is Ganymede, a moon of Jupiter. Ganymede orbits at a distance of $1.07 * 10^9$ m from the center of Jupiter with a period of about 6.18 x 10^5 s. Using this information, find the mass of Jupiter.

6. A satellite is placed in Earth orbit at an altitude of $3.75 * 10^7$ m. Find the period, in hr, of this satellite.

7. Find the altitude above the Earth at which the acceleration due to gravity is 6.52 m/s^2.

1a. 2500 N **b.** 81 N **2a.** $2.8 * 10^{-12}$ N **2b.** $2.8 * 10^{-12}$ N **3.** 1.36 m/s^2 **4.** $7.7 * 10^6$ m
5. $1.90 * 10^{27}$ kg **6**. 20 h **7.** $1.44 * 10^6$ m **8a.** $9.9 * 10^{30}$ kg **8b.** 5.0 times
9a. 7757.52 m/s 9b. 5362.66 s (1.49 h) **10.** 7765 m/s **11.** 8.57 m/s **12.** 3.1 m/s
13a. 1.14 N **13b.** .154N **14a.** 0.16 N **14b.** 6.73 N

(Mass of Earth) $m_E = 5.9737 \times 10^{24}$ kg (Mean Radius of Earth) $r_E = 6\ 371\ 000$ m
(Gravitational Constant) $G = 6.61 * 10^{-11}$ N * m^2 / kg^2
(Mass of Sun) $m_s = 1.99 * 10^{30}$ kg

8. Black holes are suspected when a visible star is being noticeably pulled by an invisible partner that is more than 3 times as massive as the sun.

(a) If a red giant (a dying star) is gravitationally accelerated at 0.075 m/s^2 toward an object that is $9.4 * 10^{10}$ m away, how large a mass does the black hole possess?

(b) How many times more massive is the object than the sun?

9. The space shuttle aims for an orbit about 250 km above the surface of the earth. In orbit, the mass of the space shuttle is about 95,000 kg.

(a) Calculate the orbital speed of the space shuttle.

(b) Calculate the orbital period of the space shuttle.

10. At a point 6.7 x $l0^6$ m from the center of the earth, g = 9.0 m/s^2. What velocity must be given to an earth satellite to send it into a circular orbit at this distance?

1a. 2500 N **b.** 81 N **2a.** $2.8 * 10^{-12}$ N **2b.** $2.8 * 10^{-12}$ N **3.** 1.36 m/s^2 **4.** $7.7 * 10^6$ m
5. $1.90 * 10^{27}$ kg **6**. 20 h **7.** $1.44 * 10^6$ m **8a.** $9.9 * 10^{30}$ kg **8b.** 5.0 times
9a. 7757.52 m/s 9b. 5362.66 s (1.49 h) **10.** 7765 m/s **11.** 8.57 m/s **12.** 3.1 m/s
13a. 1.14 N **13b.** .154N **14a.** 0.16 N **14b.** 6.73 N

(Mass of Earth) $m_E = 5.9737 \times 10^{24}$ kg (Mean Radius of Earth) $r_E = 6\ 371\ 000$ m
(Gravitational Constant) $G = 6.61 * 10^{-11}$ N * m^2 / kg^2
(Mass of Sun) $m_s = 1.99 * 10^{30}$ kg

11. A looping roller coaster ride at an amusement park has a radius of curvature of 7.50 m. At what minimum speed must the coaster be traveling at the top of the curve so the passengers will not fall out?

12. A pail of water is rotated in a vertical circle of radius 1.0 m. What is the minimum speed of the pail at the top of the circle if no water is to spill out?

13. A physics student is twirling a 50.0-g rubber stopper attached to a 0.950-m length of cord at a uniform speed in a vertical circle. If its speed is 3.50 m/s, what is the tension in the cord at (a) the bottom of the circle and (b) the top of the circle?

14. A ball on the end of a string is revolving at a uniform rate in a vertical circle of radius 96.5 cm. If its speed is 3.15 m/s and its mass is 0.335 kg, calculate the tension in the string when the ball is (a) at the top of its path, and (b) at the bottom of its path.

1a. 2500 N **b.** 81 N **2a.** $2.8 * 10^{-12}$ N **2b.** $2.8 * 10^{-12}$ N **3.** 1.36 m/s^2 **4.** $7.7 * 10^6$ m
5. $1.90 * 10^{27}$ kg **6**. 20 h **7.** $1.44 * 10^6$ m **8a.** $9.9 * 10^{30}$ kg **8b.** 5.0 times
9a. 7757.52 m/s 9b. 5362.66 s (1.49 h) **10.** 7765 m/s **11.** 8.57 m/s **12.** 3.1 m/s
13a. 1.14 N **13b.** .154N **14a.** 0.16 N **14b.** 6.73 N