Welcome back, Bill Wiecking

>>Working in AP Physics B (SC651)

ch 13 gravity

Chapter 13: Gravity and Orbits

Conceptual problems

13.C.1 (5.00) Compare planets farther from the Sun to those nearer the Sun. (a) Do the farther planets have greater or lesser orbital speed than the nearer ones? (b) How does the angular speed of the farther planets compare to that of the nearer ones?

(a)

(b)

13.C.2 (5.00) How much work is done on a satellite as it moves in a circular orbit around the Earth?

13.C.3 (5.00) According to Kepler's third law, the ratio T^2/a^3 should be the same for all objects orbiting the Sun, since the factor $4\pi^2/GM$ is the same. When this ratio is measured however, it is found to vary slightly. For instance, Jupiter's ratio is higher than Earth's by about 1%. What are the two main assumptions behind Kepler's third law that are not 100% valid in a real planetary system?

13.C.4 (7.00) From your intergalactic survey base, you observe a moon in a circular orbit about a faraway planet. You know the distance to the planet/moon system, and you determine the maximum angle of separation between the two and the period of the moon's orbit. Assuming that the moon is much less massive than the planet, explain how you can determine the mass of the planet.

13.C.5 **(7.00)** In a previous chapter, we used the equation $PE = mgh$ to represent the gravitational potential energy of an object near the Earth. In this chapter, we use the equation $PE = -GMm/r$. Explain the reasons for the differences between these two equations: Why is one expression negative and the other positive? Is r equal to h?

13.C.6 **(7.00)** Match each of the following properties of a body in circular orbit to its dependence upon the radius of the orbit: (a) velocity, (b) kinetic energy, (c) period, and (d) angular momentum.

(a) ○ r^{-1} ○ r^{-2} ○ $r^{1/2}$ ○ $r^{-1/2}$ ○ $r^{3/2}$
(b) ○ r^{-1} ○ r^{-2} ○ $r^{1/2}$ ○ $r^{-1/2}$ ○ $r^{3/2}$
(c) ○ r^{-1} ○ r^{-2} ○ $r^{1/2}$ ○ $r^{-1/2}$ ○ $r^{3/2}$
(d) ○ r^{-1} ○ r^{-2} ○ $r^{1/2}$ ○ $r^{-1/2}$ ○ $r^{3/2}$

Section 1: Newton's law of gravitation

13.1.1 **(5.00)** The Hubble Space Telescope orbits the Earth at an approximate altitude of 612 km. Its mass is 11,100 kg and the mass of the Earth is 5.97×10^{24} kg. The Earth's average radius is 6.38×10^{6} m. What is the magnitude of the gravitational force that the Earth exerts on the Hubble?

N

13.1.2 **(5.00)** A neutron star and a black hole are r m from each other at a certain point in their orbit. The neutron star has a mass of 2.78×10^{30} kg and the black hole has a mass of 9.94×10^{30} kg. What is the magnitude of the gravitational attraction between the two?

N

13.1.4 **(7.00)** The gravitational pull of the Moon is partially responsible for the tides of the sea. The Moon pulls on you, too, so if you are on a diet it is better to weigh yourself when this heavenly body is directly overhead! If you have a mass of 85.0 kg, how much less do you weigh if you factor in the force exerted by the Moon when it is directly overhead (compared to when it is just rising or setting)? Use the values 7.35×10^{22} kg for the mass of the moon, and 3.76×10^{8} m for its distance above the surface of the Earth. (For comparison, the difference in your weight would be about the weight of a small candy wrapper. And speaking of candy...)

N

Section 2: G and g

13.2.1 **(5.00)** The top of Mt. Everest is 8850 m above sea level. Assume that sea level is at the average Earth radius of 6.38×10^6 m. What is the magnitude of the gravitational acceleration at the top of Mt. Everest? The mass of the Earth is 5.97×10^{24} kg.

[ ] m/s^2

13.2.2 **(5.00)** Geosynchronous satellites orbit the Earth at an altitude of about 3.58×10^7 m. Given that the Earth's radius is 6.38×10^6 m and its mass is 5.97×10^{24} kg, what is the magnitude of the gravitational acceleration at the altitude of one of these satellites?

[ ] m/s^2

Section 9: Interactive problem: Newton's cannon

13.9.1 **(5.00)** Use the simulation in the interactive problem in Section 13.9 to determine the initial speed required to put the cannonball into circular orbit.

[ ] m/s

Section 10: Circular orbits

13.10.1 **(5.00)** The International Space Station orbits the Earth at an average altitude of 362 km. Assume that its orbit is circular, and calculate its orbital speed. The Earth's mass is 5.97×10^{24} kg and its radius is 6.38×10^6 m.

[ ] m/s

Section 15: More on ellipses and orbits

13.15.1 **(5.00)** A comet's orbit has a perihelion distance of 0.350 AU and an aphelion distance of 45.0 AU. What is the semimajor axis of the comet's orbit around the sun?

[ ] AU

Section 18: Kepler's third law

13.18.1 **(5.00)** Jupiter's semimajor axis is 7.78×10^{11} m. The mass of the Sun is 1.99×10^{30} kg. (a) What is the period of Jupiter's orbit in seconds? (b) What is the period in Earth years? Assume that one Earth year is exactly 365 days, with 24 hours in each day.

(a) [ ] s

(b) [ ] years

13.18.6 Write Kepler's third law for planets in the solar system, with *T* measured in

(7.00) years and *a* in astronomical units (AU), and explain how you arrived at the equation.

Submit answer on paper.

Section 20: Interactive problem: geosynchronous satellite

13.20.1 **(5.00)** Use the simulation in the interactive problem in Section 13.20 to calculate the (a) radius and (b) launch speed required to achieve geosynchronous orbit around the Earth.

(a) ______ km

(b) ______ m/s

Section 21: Orbits and energy

13.21.1 **(5.00)** The Hubble Space Telescope orbits the Earth at an altitude of approximately 612 km. Its mass is 11,100 kg and the mass of the Earth is 5.97×10^{24} kg. The Earth's radius is 6.38×10^{6} m. Assume the Hubble's orbit is circular. (a) What is the gravitational potential energy of the Earth-Hubble system? (Assume that it is zero when their separation is infinite.) (b) What is the Hubble's *KE*? (c) What is the Hubble's total energy?

(a) ______ J

(b) ______ J

(c) ______ J

Section 26: Escape speed

13.26.1 **(5.00)** Calculate the escape speed from the surface of Venus, whose radius is 6.05×10^{6} m and mass is 4.87×10^{24} kg. Neglect the influence of the Sun's gravity.

______ m/s

13.26.5 **(7.00)** The Schwarzschild radius of a black hole can loosely be defined as the radius at which the escape speed equals the speed of light. Anything closer to the black hole than this radius can never escape, because nothing can travel faster than light in a vacuum. Not even light itself can escape, hence the name "black hole". (a) Find the Schwarzschild radius of a black hole with a mass equal to five times that of the Sun. This is a typical value for a "stellar-mass" black hole. The Sun's mass is 1.99×10^{30} kg. (b) Find the Schwarzschild radius of a black hole with a mass of one billion Suns. This is the type of black hole found at the centers of the largest galaxies.

(a) ______ m

(b) ______ m

Additional problems

13.A.1 **(7.00)** A satellite in geosynchronous orbit does not change its position in the sky as seen from Earth. This means it orbits the Earth once each day, moving in the same direction as the Earth's rotation. (a) What is the altitude of a satellite in geosynchronous orbit? (The radius of the Earth is 6.38×10^6 m and its mass is 5.97×10^{24} kg.) (b) What is its speed?

(a) ______ m

(b) ______ m/s

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