CK-12 Physics Concepts - Intermediate
Answer Key

Chapter 6: Universal Gravitation

6.1 Kepler's Laws of Planetary Motion

Practice

Questions

1. What is the shape of a planetary orbit?
2. How are the areas swept out by the line able to be equal, when the line is much longer at sometimes than others?
3. What is the T in Kepler's Third Law? What is the r?

Answers

1. Planetary orbits are ellipsoidal.
2. The orbiting object (planet) travels faster on the side of the ellipse closer to the larger central object (star).
3. The T is the period of the orbiting object in units of time. The r is the average orbital radius of the orbiting satellite.

Review

Questions

1. The average mean distance of the earth from the sun is 149.6×10^6 km and the period of the earth is 1.0 year. The average mean distance of Saturn from the sun is 1427×10^6 km. Using Kepler's third law, calculate the period of Saturn.
2. Which of the following is one of Kepler's Laws of Planetary Motion?
   a. Planets move in elliptical orbits with the Sun at one focus.
   b. Gravitational force between two objects decreases as the distance squared.
   c. An object in motion remains in motion.
   d. Inner planets orbit in a different direction that outer ones.
3. If a planet's orbital speed is 20 km/s when it is at its average distance from the sun, which is most likely orbital speed when it is nearest the sun?
   a. 10 km/s b. 15 km/s c. 20 km/s d.25 km/s

Answers

1. $\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$

$\left(\frac{T_1}{1yr}\right)^2 = \left(\frac{1427 \times 10^6}{149.6 \times 10^6}\right)^3$

$T_1 = \sqrt{\left(\frac{1427 \times 10^6}{149.6 \times 10^6}\right)^3} = 29.46yr$

2. a.
3. d. Since the average speed is, inevitably, slower than the speed when the planet is nearest the sun, we know that the answer must be d.

6.2 Universal Law of Gravity

Practice

Questions

1. What is gravity?
2. What caused the sun to form?
3. What is the relationship between the strength of a gravitational force and distance?
4. What is the relationship between the strength of a gravitational force and mass?

Answers

1. Gravity is a long-range attractive force between all objects with energy.
2. The sun formed because of gravity.
3. The strength of gravity decreases by the square of the distance. As a distance doubles, the gravitational force decreases by a factor of four.
4. The strength of gravity increases proportionally with increases in mass.

Review

Questions

1. The earth is attracted to the sun by the force of gravity. Why doesn't the earth fall into the sun?
2. If the mass of the earth remained the same but the radius of the earth shrank to one-half its present distance, what would happen to the force of gravity on an object that was resting on the surface of the earth?
3. Lifting an object on the moon requires one-sixth the force that would be required to lift the same object on the earth because gravity on the moon is one-sixth that on earth. What about horizontal acceleration? If you threw a rock with enough force to

accelerate it at 1.0 m/s^2 horizontally on the moon, how would the required force compare to the force necessary to accelerate the rock in the same way on Earth?

4. The mass of the earth is 5.98×10^{24} kg and the mass of the moon is 7.35×10^{22} kg. If the distance between the earth and the moon is 384,000 km, what is the gravitational force on the moon?

Answers

1. Since the direction of the earth's velocity is perpendicular to the gravitational force pulling the earth towards the sun, the inertia of that motion keeps the planet from falling into the sun.
2. If the radius of the earth shrank to one half its current size, the strength of gravity on the surface would quadruple.
3. The horizontal acceleration is independent of the gravitational force; the same about of force would be necessary to accelerate the rock to 1.0 m/s^2 on earth as is necessary on the moon.

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

4. $$F = 6.67 \times 10^{-11} Nm^2/kg^2 \frac{(5.98 \times 10^{24} kg)(7.35 \times 10^{22} kg)}{\left((384000 km)\left(\frac{1000m}{1km}\right)\right)^2} = 1.99 \times 10^{20} N$$

6.3 Orbital Motion

Practice

Questions

1. What are some of the things the astronauts are learning to do/practicing in this video?
2. These astronauts are in a plane, flying over Earth. How do they simulate weightlessness?
3. How is a falling elevator similar to an orbiting satellite?
4. Why does your weight double when the elevator is rising with an acceleration of *g*?
5. Why doesn't the pen fall when you drop it while weightless?

Answers

1. The astronauts practice moving around while weightless. He practices moving from one side of the shuttle to another, moving up and down in the shuttle, moving a large, heavy object, moving around the perimeter using his hands and arms instead of legs, putting on a space suit, and floating in weightlessness.
2. The plane flies high into the atmosphere and then drops straight down towards the planet. When it is falling, the plane and the astronauts inside it are all in

freefall, thus giving the astronauts a short period of time to experience weightlessness.

3. A falling elevator, like an orbiting satellite, is in free fall.
4. Your weight doubles when the elevator is rising because the scale is reading the normal force opposing your weight. The scale is reading your original weight of *mg*, in addition to your mass times the vertical acceleration of the elevator. Thus, the weight measured by the scale reading *2mg*.
5. The pen falls at the rate of $9.8 m/s^2$, which is the same rate at which you are falling. The pen doesn't appear to drop because it is falling at the same rate you are.

Review

Questions

1. Sally's mass on the earth is 50. kg.
   a. What is her weight on the earth?
   b. What is her weight on the moon?
   c. What is her mass on the moon?
2. The radius of the planet Mercury is 2.43×10^6 m and its mass is 3.2×10^{23} kg.
   a. Find the speed of a satellite in orbit 265,000 m above the surface.
   b. Find the period of the satellite.
3. A geosynchronous orbit is an orbit in which the satellite remains over the same spot on the earth as the earth turns. This is accomplished by matching the velocity of the satellite to the velocity of the turning earth. The orbital radius of a geosynchronous satellite is 4.23×10^7m (measured from the center of the earth).
   a. What is the speed of the satellite in orbit?
   b. What is its period?

Answers

1.
   a. Sally's weight on the earth is 490 N.
   b. Gravity on the moon is 1/6 that on the earth. Thus, Sally's weight on the moon is 81.6667 N.
   c. Sally's mass on the moon is the same as on earth: 50 kg.
2.
   a. As in the first example, use the equation $v = \sqrt{\frac{Gm_M}{r}}$, where m_M is the mass of mercury and r is the radius of the satellite's orbit. Using this equation, we get a velocity of 2800 m/s.
   b. The period of the satellite is found using the equation $T = \frac{2pr}{v}$. Using this equation, T = 6000 seconds.
3. Use the same equations as are used above. The mass of the earth is 5.98×10^{24} kg.
   a. v = 3070 m/s

b. T = 86551 sec (apx 1 day)