Ch 13 Supplemental [Edit]

Overview Summary View Diagnostics View **Print View with Answers**

Ch 13 Supplemental

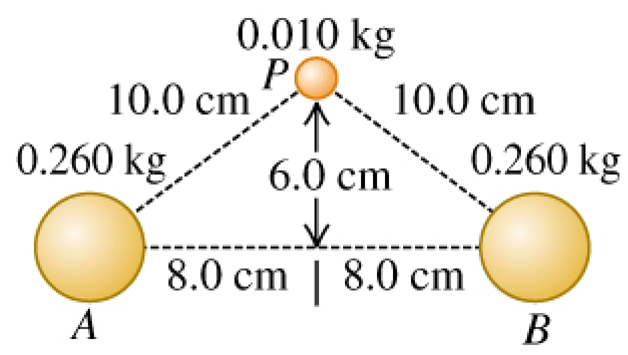
Due: 6:59pm on Friday, April 28, 2017

To understand how points are awarded, read the Grading Policy for this assignment.

Exercise 13.5

Description: Two uniform spheres, each of mass 0.260 kg, are fixed at points A and B (the figure). (a) Find the magnitude of the initial acceleration of a uniform sphere with mass 0.010 kg if released from rest at point P and acted on only by forces of...

Two uniform spheres, each of mass 0.260 kg, are fixed at points A and B (the figure).



Part A

Find the magnitude of the initial acceleration of a uniform sphere with mass 0.010 kg if released from rest at point P and acted on only by forces of gravitational attraction of the spheres at A and B.

Express your answer using two significant figures.

ANSWER:

a = 2.1×10^{-9} $\mathrm{m/s^2}$

Part B

Find the direction of the initial acceleration of a uniform sphere with mass 0.010 kg.

ANSWER:

- upward
- to the right
- (selected) downward
- to the left

Exercise 13.16

Description: Jupiter's moon Io has active volcanoes (in fact, it is the most volcanically active body in the solar system) that eject material as high as 500 km (or even higher) above the surface. Io has a mass of 8.93*10^22 kg and a radius of 1821 km ...

Jupiter's moon Io has active volcanoes (in fact, it is the most volcanically active body in the solar system) that eject material as high as 500 km (or even higher) above the surface. Io has a mass of 8.93×10^{22} kg and a radius of 1821 km . For this calculation, ignore any variation in gravity over the 500-km range of the debris.

Part A

How high would this material go on earth if it were ejected with the same speed as on Io?

Express your answer to three significant figures and include the appropriate units.

ANSWER:

h = 91.6km

Also accepted: 91.7km, 91.6km

Problem 13.48

Description: At a certain instant, the earth, the moon, and a stationary m spacecraft lie at the vertices of an equilateral triangle whose sides are 3.84 * 10^5 (km) in length. (a) Find the magnitude of the net gravitational force exerted on the spacecraft by the ...

At a certain instant, the earth, the moon, and a stationary 1500 kg spacecraft lie at the vertices of an equilateral triangle whose sides are $3.84\times10^5\ \mathrm{km}$ in length.

Part A

Find the magnitude of the net gravitational force exerted on the spacecraft by the earth and moon.

Express your answer to three significant figures.

ANSWER:

$$F = \frac{6.673\cdot10^{-11} m\cdot5.97\cdot10^{24}}{(3.84\cdot10^{8})^2}\sqrt{1+\left(\frac{7.35}{597}\right)^2+\frac{7.35}{597}} = 4.08\ \mathrm{N}$$

Part B

Find the direction of the net gravitational force exerted on the spacecraft by the earth and moon. State the direction as an angle measured from a line connecting the earth and the spacecraft.

Express your answer to three significant figures.

ANSWER:

0.607 $^\circ$

Part C

What is the minimum amount of work that you would have to do to move the spacecraft to a point far from the earth and moon? You can ignore any gravitational effects due to the other planets or the sun.

Express your answer to three significant figures.

ANSWER:

$W = \dfrac{6.673m\left(5.97\cdot 10^2 + 7.35\right)\left(10^3\right)}{3.84}$ = 1.58×10^9 J

Problem 13.49

Description: Many satellites are moving in a circle in the earth's equatorial plane. They are at such a height above the earth's surface that they always remain above the same point. (a) Find the altitude of these satellites above the earth's surface. (Such an...

Many satellites are moving in a circle in the earth's equatorial plane. They are at such a height above the earth's surface that they always remain above the same point.

Part A

Find the altitude of these satellites above the earth's surface. (Such an orbit is said to be *geosynchronous*.)

ANSWER:

h = 3.58×10^7 m

Problem 13.54

Description: (a) Suppose you are at the earth's equator and observe a satellite passing directly overhead and moving from west to east in the sky. Exactly t hours later, you again observe this satellite to be directly overhead. Assume a circular orbit. How far...

Part A

Suppose you are at the earth's equator and observe a satellite passing directly overhead and moving from west to east in the sky. Exactly 13.0 hours later, you again observe this satellite to be directly overhead. Assume a circular orbit. How far above the earth's surface is the satellite's orbit?

ANSWER:

$$h = \sqrt[3]{\left(6.67 \cdot 10^{-11} \cdot 5.98 \cdot 10^{24} \left(\frac{\frac{t \cdot 24}{t+24} \cdot 3600}{\frac{2}{\pi}}\right)^2\right)} - 6380 \cdot 10^3 = 1.47 \times 10^7 \quad \mathrm{m}$$

Part B

You observe another satellite directly overhead and traveling east to west. This satellite is again overhead in 13.0 hours. How far is this satellite's orbit above the surface of the earth?

ANSWER:

$$h = \sqrt[3]{\left(6.67 \cdot 10^{-11} \cdot 5.98 \cdot 10^{24} \left(\frac{\frac{t \cdot 24}{24-t} \cdot 3600}{\frac{2}{\pi}}\right)^2\right)} - 6380 \cdot 10^3 = 4.08 \times 10^7 \quad \mathrm{m}$$

Problem 13.59

Description: An unmanned spacecraft is in a circular orbit around the moon, observing the lunar surface from an altitude of h. To the dismay of scientists on earth, an electrical fault causes an on-board thruster to fire, decreasing the speed of the spacecraft by...

An unmanned spacecraft is in a circular orbit around the moon, observing the lunar surface from an altitude of 56.0 km . To the dismay of scientists on earth, an electrical fault causes an on-board thruster to fire, decreasing the speed of the spacecraft by 21.0 $\mathrm{m/s}$.

Part A

If nothing is done to correct its orbit, with what speed (in km/h) will the spacecraft crash into the lunar surface?

ANSWER:

$$v = 3.6\sqrt{2\left(\frac{6.673 \cdot 7.35\left(10^{11}\right)}{1.74 \cdot 10^6} + 0.5\left(\sqrt{\frac{6.673 \cdot 7.35\left(10^{11}\right)}{1.74 \cdot 10^6 + h}} - v\right)^2 - \frac{6.673 \cdot 7.35 \cdot 10^{11}}{1.74 \cdot 10^6 + h}\right)} = 6060 \quad \mathrm{km/h}$$

Problem 13.65

Description: (a) Comets travel around the sun in elliptical orbits with large eccentricities. If a comet has speed v_0 when at a distance of d_1 from the center of the sun, what is its speed when at a distance of d_2.

Part A

Comets travel around the sun in elliptical orbits with large eccentricities. If a comet has speed 2.3×10^4 $\mathrm{m/s}$ when at a distance of 2.6×10^{11} m from the center of the sun, what is its speed when at a distance of 4.9×10^{10} m .

Express your answer using two significant figures.

ANSWER:

$v = \sqrt{{v_0}^2 + 2\cdot 6.673\cdot 10^{-11}\cdot 1.99\cdot 10^{30}\left(\frac{1}{d_2} - \frac{1}{d_1}\right)}$ = 7.0×10^4 $\mathrm{m/s}$

Problem 13.67

Description: Consider a spacecraft in an elliptical orbit around the earth. At the low point, or perigee, of its orbit, it is R_p above the earth's surface; at the high point, or apogee, it is R_a above the earth's surface. (a) What is the period of the...

Consider a spacecraft in an elliptical orbit around the earth. At the low point, or perigee, of its orbit, it is 400 km above the earth's surface; at the high point, or apogee, it is 2000 km above the earth's surface.

Part A

What is the period of the spacecraft's orbit?

ANSWER:

$T = 3.14\sqrt{\frac{(R_p + R_a + 2\cdot 6380\cdot 10^3)^3}{2\cdot 6.67\cdot 10^{-11}\cdot 5.98\cdot 10^{24}}}$ = 6560 s

Part B

Using conservation of angular momentum, find the ratio of the spacecraft's speed at perigee to its speed at apogee.

ANSWER:

$\frac{v_{\mathrm{perigee}}}{v_{\mathrm{apogee}}} = \frac{R_a + 6380\cdot 10^3}{R_p + 6380\cdot 10^3}$ = 1.24

Part C

Using conservation of energy, find the speed at perigee and the speed at apogee.

Enter your answers numerically separated by a comma.

ANSWER:

$v_{\mathrm{perigee}}, v_{\mathrm{apogee}} = \sqrt{\frac{\frac{2\cdot 6.67\cdot 10^{-11}\cdot 5.98\cdot 10^{24}}{R_a + R_p + 2\cdot 6380\cdot 10^3}\left(R_a + 6380\cdot 10^3\right)}{R_p + 6380\cdot 10^3}}, \sqrt{\frac{\frac{2\cdot 6.67\cdot 10^{-11}\cdot 5.98\cdot 10^{24}}{R_a + R_p + 2\cdot 6380\cdot 10^3}\left(R_p + 6380\cdot 10^3\right)}{R_a + 6380\cdot 10^3}}$ = 8060, 6520 $\mathrm{m/s}$

Part D

It is necessary to have the spacecraft escape from the earth completely. If the spacecraft's rockets are fired at perigee, by how much would the speed have to be increased to achieve this?

ANSWER:

$$\Delta v_{\text{perigee}} = \sqrt{\frac{2\cdot 6.67\cdot 10^{-11}\cdot 5.98\cdot 10^{24}}{R_p + 6380\cdot 10^3}}\left(1 - \sqrt{\frac{R_a + 6380\cdot 10^3}{R_a + R_p + 2\cdot 6380\cdot 10^3}}\right) = 2780 \quad \mathrm{m/s}$$

Part E

What if the rockets were fired at apogee?

ANSWER:

$$\Delta v_{\text{apogee}} = \sqrt{\frac{2\cdot 6.67\cdot 10^{-11}\cdot 5.98\cdot 10^{24}}{R_a + 6380\cdot 10^3}}\left(1 - \sqrt{\frac{R_p + 6380\cdot 10^3}{R_a + R_p + 2\cdot 6380\cdot 10^3}}\right) = 3230 \quad \mathrm{m/s}$$

Part F

Which point in the orbit is more efficient to use?

ANSWER:

3616 Character(s) remaining

Calculation shows that (v_escape - v_apogee) > (v_escape - v_perigee), where v_escape is the escape speed for the certain point, so it is more efficient to fire the rockets at perigee.

Problem 13.75

Description: A shaft is drilled from the surface to the center of the earth as in the example 13.10 (section 13.6 in the textbook), make the unrealistic assumption that the density of the earth is uniform. With this approximation, the gravitational force on an...

A shaft is drilled from the surface to the center of the earth as in the example 13.10 (section 13.6 in the textbook), make the unrealistic assumption that the density of the earth is uniform. With this approximation, the gravitational force on an object with mass m, that is inside the earth at a distance r from the center, has magnitude $F_{\mathrm{g}} = Gm_{\mathrm{E}}mr/R_{\mathrm{E}}^3$ (as shown in the example 12.10) and points toward the center of the earth.

Part A

Derive an expression for the gravitational potential energy $U(r)$ of the object-earth system as a function of the object's distance from the center of the earth. Take the potential energy to be zero when the object is at the center of the earth.

ANSWER:

$U(r) = \frac{G m_E m r^2}{2 (R_E)^3}$

Part B

If an object is released in the shaft at the earth's surface, what speed will it have when it reaches the center of the earth?

Express your answer using two significant figures.

ANSWER:

$v =$ 7900 $\mathrm{m/s}$