Chapter 10 Drill

The answers and explanations can be found in Chapter 17.

Section I: Multiple Choice

1. An object has an altitude of 2 times the Earth's radius, r_E, and experiences some force of gravity, $F_{g,0}$. If the object's altitude is doubled, then the new force of gravity will be

   (A) $4F_{g,0}$

   (B) $\left(\frac{25}{9}\right)F_{g,0}$

   (C) $2F_{g,0}$

   (D) $\left(\frac{1}{2}\right)F_{g,0}$

   (E) $\left(\frac{9}{25}\right)F_{g,0}$

2. At the surface of Earth, an object of mass m has weight w. If this object is transported to a height above the surface that's twice the radius of Earth, then, at the new location,

   (A) its mass is $m/2$ and its weight is $w/2$
   (B) its mass is m and its weight is $w/2$
   (C) its mass is $m/2$ and its weight is $w/4$
   (D) its mass is m and its weight is $w/4$
   (E) its mass is m and its weight is $w/9$

3. A moon of mass m orbits a planet of mass $100m$. Let the strength of the gravitational force exerted by the planet on the moon be denoted by F_1, and let the strength of the gravitational force exerted by the moon on the planet be F_2. Which of the following is true?

   (A) $F_1 = 100F_2$
   (B) $F_1 = 10F_2$
   (C) $F_1 = F_2$
   (D) $F_2 = 10F_1$
   (E) $F_2 = 100F_1$

4. Humans cannot survive for long periods under gravity more than 4 times what we experience on Earth. If a planet were discovered with the same mass as Earth, what is the smallest radius it could have (in terms of Earth's radius, r_E) without being dangerous to humans?

   (A) $\frac{1}{8}r_E$

   (B) $\frac{1}{4}r_E$

   (C) $\frac{1}{2}r_E$

   (D) $2\,r_E$

   (E) $4\,r_E$

5. Humans cannot survive for long periods under gravity more than 4 times what we experience on Earth. If a planet were discovered with the same mass as Earth, what is the smallest volume it could have (in terms of Earth's volume, V_E), without being dangerous to humans? Assume that the planet is a sphere.

   (A) $\frac{1}{8}V_E$

   (B) $\frac{1}{4}V_E$

   (C) $\frac{1}{2}V_E$

   (D) $2\,V_E$

   (E) $4\,V_E$

6. A moon of Jupiter has a nearly circular orbit of radius R and an orbit period of T. Which of the following expressions gives the mass of Jupiter?

   (A) $2\pi R/T$
   (B) $4\pi^2R/T^2$
   (C) $2\pi R^3/(GT^2)$
   (D) $4\pi R^2/(GT^2)$
   (E) $4\pi^2R^3/(GT^2)$

7. Two large bodies, Body A of mass m and Body B of mass $4m$, are separated by a distance R. At what distance from Body A, along the line joining the bodies, would the gravitational force on an object be equal to zero? (Ignore the presence of any other bodies.)

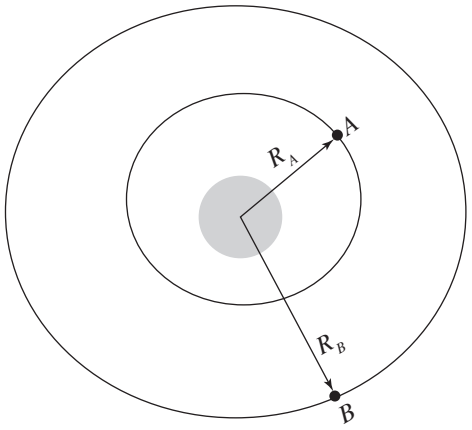
   (A) $R/16$
   (B) $R/8$
   (C) $R/5$
   (D) $R/4$
   (E) $R/3$

8. The mean distance from Saturn to the Sun is 9 times greater than the mean distance from Earth to the Sun. How long is a Saturn year?

   (A) 18 Earth years
   (B) 27 Earth years
   (C) 81 Earth years
   (D) 243 Earth years
   (E) 729 Earth years

9. The Moon has mass M and radius R. A small object is dropped from a distance of $3R$ from the Moon's center. The object's impact speed when it strikes the surface of the Moon is equal to $\sqrt{kGM/R}$ for $k =$

   (A) $\frac{1}{3}$
   (B) $\frac{2}{3}$
   (C) $\frac{3}{4}$
   (D) $\frac{4}{3}$
   (E) $\frac{3}{2}$



10. Two satellites, A and B, orbit a planet in circular orbits having radii R_A and R_B, respectively, as shown above. If $R_B = 3R_A$, the velocities v_A and v_B of the two satellites are related by which of the following?

    (A) $v_B = v_A$
    (B) $v_B = 3v_A$
    (C) $v_B = 9v_A$
    (D) $v_B = v_A\sqrt{3}$
    (E) $v_B = \frac{v_A}{\sqrt{3}}$

Section II: Free Response

1. Consider two uniform spherical bodies in deep space. Sphere 1 has mass m_1 and Sphere 2 has mass m_2. Starting from rest from a distance R apart, they are gravitationally attracted to each other.

   (a) Compute the acceleration of Sphere 1 when the spheres are a distance $R/2$ apart.

   (b) Compute the acceleration of Sphere 2 when the spheres are a distance $R/2$ apart.

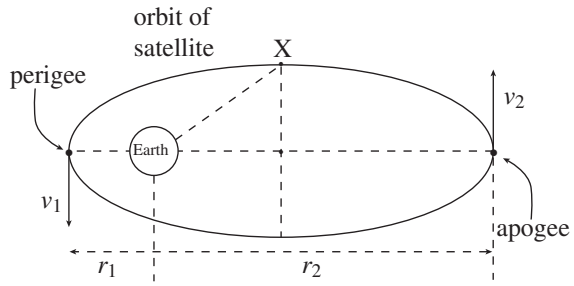
   (c) Compute the speed of Sphere 1 when the spheres are a distance $R/2$ apart.

   (d) Compute the speed of Sphere 2 when the spheres are a distance $R/2$ apart.

   Now assume that these spheres orbit their center of mass with the same orbit period, T.

   (e) Determine the radii of their orbits. Write your answer in terms of m_1, m_2, T, and fundamental constants.

2. A satellite of mass m is in the elliptical orbit shown below around Earth (radius r_E, mass M). Assume that $m << M$.



   (a) Determine v_1, the speed of the satellite at perigee (the point of the orbit closest to Earth). Write your answer in terms of r_1, r_2, M, and G.

   (b) Determine v_2, the speed of the satellite at apogee (the point of the orbit farthest from Earth). Write your answer in terms of r_1, r_2, M, and G.

   (c) Express the ratio v_1/v_2 in simplest terms.

   (d) What is the satellite's angular momentum (with respect to Earth's center) when it's at apogee?

   (e) Determine the speed of the satellite when it's at the point marked X in the figure.

   (f) Determine the period of the satellite's orbit. Write your answer in terms of r_1, r_2, M, and fundamental constants.