**Your Name:** ______________________________

**PHY203**
**Exam #4**
**Chapters 5,9,10,14**
**Mon., 12/9/13**

# Solutions

1. A planet has a mass of $7.50 \times 10^{25}$ kg and a radius of $5.00 \times 10^{3}$ km.
a. Find the magnitude of the acceleration due to gravity on the surface of the planet.

$$g = \frac{GM}{R^2} = \frac{(6.67x10^{-11})(7.50x10^{25})}{(5.00x10^{6}m)^2} = 200 m/s^2$$ **10**

b. Find the escape speed from the surface of the planet.

$$\frac{1}{2}mv_e{}^2 - \frac{mGM}{R} = 0$$
$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2(6.67x10^{-11})(7.50x10^{25})}{(5.00x10^{6}m)}} =$$ **10**
$$4.47x10^4 m/s$$

c. If a 550 kg rocket is propelled from the surface with an initial speed of 25.0 km/s, find the greatest height above the planet's surface that the rocket reaches.

$$\frac{1}{2}mv^2 - \frac{mGM}{R} = -\frac{mGM}{R+h}$$
$$v^2 = \frac{2GM}{R}[1 - \frac{1}{1+h/R}] = v_e{}^2[1 - \frac{1}{1+h/R}]$$ **15**
$$h = 0.460R = 2.30x10^6 m$$

2. A simple harmonic oscillator consisting of a block of mass 2.50 kg moving in the x-direction has amplitude 6.50 cm and period 3.00 s.

a. Find the frequency and angular frequency of the oscillator.

$$f = \frac{1}{T} = \frac{1}{3.00} = 0.333 Hz$$
$$\omega = 2\pi f = 2\pi(0.333) = 2.09 rad/s$$

**5**

b. Write an equation for the position of the block vs. time.

x(t) = (0.0650)cos(2.09t) **5**

c. Write an equation for the velocity of the block vs. time.

$$v = \frac{dx}{dt} = -\omega A \sin(\omega t) = -(2.09)(0.0650)\sin(2.09t)$$
$$= -0.136 \sin(2.09t) m/s$$

**10**

d. Find the maximum speed of the block.

$$v = \frac{dx}{dt} = -\omega A \sin(\omega t)$$
$$v_{max} = \omega A = 0.136 m/s$$

**5**

e. Find the kinetic energy of the block at a time of 5.50 s.

$$v(5.50) = -0.136 \sin(2.09 x 5.50)$$
$$= 0.119 m/s$$
$$K = \frac{1}{2}mv^2 = \frac{1}{2}(2.50)(-0.119)^2 = 1.78 x 10^{-2} J$$

**10**

3. A simple pendulum on the surface of Earth consists of a block of mass 2.50 kg suspended on a string of length 3.50 m. The amplitude of the pendulum is 25.0°.

a. Find the period of the pendulum.

$$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{3.50}{9.81}} = 3.75s$$ **10**

b. Find the frequency and angular frequency of the pendulum.

$$f = \frac{1}{T} = \frac{1}{3.75} = 0.266Hz$$
$$\omega = 2\pi f = 2\pi(0.266) = 1.67rad/s$$ **5**

A pendulum on the surface of the Earth consists of a thin rod of mass 2.50 kg and length 3.50 m. It pivots about an axis through one end. The amplitude of the pendulum is 25.0°.

c. Find the period of the pendulum.

$$T = 2\pi\sqrt{\frac{I}{MgD}} = 2\pi\sqrt{\frac{\frac{1}{3}ML^2}{Mg\frac{L}{2}}} = 2\pi\sqrt{\frac{2L}{3g}}$$ **15**

$$= 2\pi\sqrt{\frac{2(3.50)}{3(9.81)}} = 3.07s$$

Alternate

1. A planet has a mass of 6.50x10$^{25}$ kg and a radius of 4.00x10$^{3}$ km.

a. Find the magnitude of the acceleration due to gravity on the surface of the planet.

$$g = \frac{GM}{R^2} = \frac{(6.67x10^{-11})(6.50x10^{25})}{(4.00x10^6 m)^2} = 271 m/s^2$$ **10**

b. Find the escape velocity from the surface of the planet.

$$\frac{1}{2}mv_e{}^2 - \frac{mGM}{R} = 0$$

$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2(6.67x10^{-11})(6.50x10^{25})}{(4.00x10^6 m)}} =$$ **10**

$$4.65x10^4 m/s$$

c. If a 650 kg rocket is propelled from the surface with an initial speed of 35.0 km/s, find the greatest height above the planet's surface that the rocket reaches.

$$\frac{1}{2}mv^2 - \frac{mGM}{R} = -\frac{mGM}{R+h}$$

$$v^2 = \frac{2GM}{R}[1 - \frac{1}{1+h/R}] = v_e{}^2[1 - \frac{1}{1+h/R}]$$ **15**

$$h = 1.31R = 5.24x10^6 m$$

2. A simple harmonic oscillator consisting of a block of mass 3.50 kg moving in the x-direction has amplitude 7.50 cm and period 4.00 s.

a. Find the frequency and angular frequency of the oscillator.

$$f = \frac{1}{T} = \frac{1}{4.00} = 0.250 Hz$$
$$\omega = 2\pi f = 2\pi(0.250) = 1.57 rad/s$$

**5**

b. Write an equation for the position of the block vs. time.

x(t) = (0.0750)cos(1.57t) **5**

c. Write an equation for the velocity of the block vs. time.

$$v = \frac{dx}{dt} = -\omega A \sin(\omega t) = -(1.57)(0.0750)\sin(1.57t)$$
$$= -0.118 \sin(1.57t) m/s$$

**10**

d. Find the maximum speed of the block.

$$v = \frac{dx}{dt} = -\omega A \sin(\omega t)$$
$$v_{\max} = \omega A = 0.118 m/s$$

**5**

e. Find the kinetic energy of the block at a time of 4.50 s.

$$v(4.50) = -0.118 \sin(1.57 x 4.50)$$
$$= 8.31 x 10^{-2} m/s$$
$$K = \frac{1}{2} m v^2 = \frac{1}{2}(3.50)(8.31 x 10^{-2})^2 = 1.21 x 10^{-2} J$$

**10**

3. A simple pendulum on the surface of Earth consists of a block of mass 3.50 kg suspended on a string of length 4.50 m. The amplitude of the pendulum is 35.0°.

a. Find the period of the pendulum.

$$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{4.50}{9.81}} = 4.26s$$

**10**

b. Find the frequency and angular frequency of the pendulum.

$$f = \frac{1}{T} = \frac{1}{4.26} = 0.235Hz$$

$$\omega = 2\pi f = 2\pi(0.235) = 1.48rad/s$$

**5**

A pendulum on the surface of the Earth consists of a thin rod of mass 3.50 kg and length 4.50 m. It pivots about an axis through one end. The amplitude of the pendulum is 35.0°.

c. Find the period of the pendulum.

$$T = 2\pi\sqrt{\frac{I}{MgD}} = 2\pi\sqrt{\frac{\frac{1}{3}ML^2}{Mg\frac{L}{2}}} = 2\pi\sqrt{\frac{2L}{3g}}$$

**15**

$$= 2\pi\sqrt{\frac{2(4.50)}{3(9.81)}} = 3.48s$$