HW 3 Solutions

Due October 16, 2009

1. ou have a spring with constant $k = 200N/m$ attached to a 3kg mass. What is the:

   (a) Angular frequency?
   $\omega = \sqrt{\frac{k}{m}} = 8.16s^{-1}$

   (b) Frequency?
   $f = \frac{\omega}{2\pi} = 1.29Hz$

   (c) Period?
   $P = \frac{1}{f} = 0.77s$

   (d) How long would you have to make a pendulum such that it swung at exactly the same rate as the oscillator?
   We want to make the pendulum frequency the same as the spring frequency: $\sqrt{\frac{k}{m}} = \sqrt{\frac{g}{l}} \Rightarrow \frac{k}{m} = \frac{g}{l} \Rightarrow l = \frac{mg}{k} = 0.15m$

   (e) If you hung the mass from the spring, how much would the spring stretch?
   We have to balance the gravitational force with the spring force: $mg = kx \Rightarrow x = \frac{mg}{k} = 0.15m$

2. Air pressure is approximately $10^5 N/m^2$. Assuming the surface of the earth to be smooth and gravitational acceleration=g (9.8 m/s^2 over all of the atmosphere):

   (a) The earth has a radius of 6.4×10^6m. What is the surface area of the earth?
   The surface area for a sphere is given by: $A = 4\pi R^2 = 5.15 \times 10^{14} m^2$

   (b) What is the total Force of the atmosphere on the surface of the earth?
   The force is the pressure times the area: $F_{air} = A * 10^5 \frac{N}{m^2} = 5.15 \times 10^{19} N$

   (c) Since the net momentum of the atmosphere is constant (zero, actually), there must be no net force, and thus, by Newton's 3rd law, the force on the atmosphere from the earth must be equal and opposite to your answer in part b). Also, since the only other game in town in gravity – what's the total mass of the atmosphere?
   Balancing this force with gravity: $F_g = mg = F_{air} \Rightarrow m = \frac{F_{air}}{g} = 5.25 \times 10^{18} kg$

3. 4.HW.75 ; In addition, please draw a free body diagram for all three blocks.

   See free body diagrams on the last page.

   a) Since the given force is moving all three blocks the acceleration will just be the force divided by the total mass: $a = \frac{F}{m_1+m_2+m_3}$

   b) By Newton's third law the forces between block one and two will be equal and opposite, and same for the forces between block two and three. The force on mass three must be equal to $m_3 a \Rightarrow F_{32} = m_3 a$. The net force on block two must be equal to $m_2 a \Rightarrow F_{21} - F_{23} = m_2 a \Rightarrow F_{21} = (m_2 + m_3)a$

   c) When you switch to pulling on the third block the acceleration will be the same but the forces on block two will change: $F_{12} = m_1 a$ and $F_{21} - F_{23} = m_2 a \Rightarrow F_{23} = -(m_1 + m_2)a$

4. 4.HW.86

   The person is traveling in a circle so the force he has to hold on with is equal to the centripetal force. His velocity is just the distance he travels divided by the time it takes. We know that in one period of the motion he travels once around the circle: $d = 2\pi R \Rightarrow v = \frac{2\pi R}{T} \Rightarrow F_c = \frac{mv^2}{R} = \frac{mR4\pi^2}{T^2} = 43N$

   The net force on the person must be 43N, to keep moving in a circle.

5. 4.HW.101

   a) The general equation for the period is: $T = 2\pi\sqrt{\frac{m}{k}}$ If the mass is doubled then T will increase $\sqrt{2}$.

   b) Adding another spring is like doubling k. This makes T decrease by $\sqrt{2}$.

   c) Cutting a spring in half makes it so it can not stretch as much, this is also like doubling k. This makes T decrease by $\sqrt{2}$.

   d) Moving this to the Moon will not cause the period to change.

   3.