PROBLEM SET 1 CHAP. 13

2. Each half-spring will have twice the spring constant of the full spring, as shown by the following argument. The force exerted by a spring is proportional to the separation of the coils as the spring is extended. Imagine that we extend a spring by a given distance and measure the distance between coils. We then cut the spring in half. If one of the half-springs is now extended by the same distance, the coils will be twice as far apart as they were for the complete spring. Thus, it takes twice as much force to stretch the half-spring, from which we conclude that the half-spring has a spring constant which is twice that of the complete spring.

13. Solution in book

13.5 Since object A is in equilibrium, the net force acting on it must be zero, giving

$$F_1 + F_2 = k_1 x + k_2 x = 80.0\text{ N}$$

Hence, $x = \dfrac{80.0\text{ N}}{k_1 + k_2} = \dfrac{80.0\text{ N}}{40.0\text{ N/cm} + 25.0\text{ N/cm}} = \boxed{1.23\text{ cm}}$

13.8 (a) $k = \dfrac{F_{max}}{x_{max}} = \dfrac{230\text{ N}}{0.400\text{ m}} = \boxed{575\text{ N/m}}$

(b) $work\ done = PE_s = \dfrac{1}{2}kx^2 = \dfrac{1}{2}(575\text{ N/m})(0.400)^2 = \boxed{46.0\text{ J}}$

13.13 An unknown quantity of mechanical energy is converted into internal energy during the collision. Thus, we apply conservation of momentum from just before to just after the collision and obtain $mv_i + M(0) = (M+m)V$, or the speed of the block and embedded bullet just after collision is

$$V = \left(\frac{m}{M+m}\right)v_i = \left(\frac{10.0\times10^{-3}\text{ kg}}{2.01\text{ kg}}\right)(300\text{ m/s}) = 1.49\text{ m/s}.$$

Now, we use conservation of mechanical energy from just after collision until the block comes to rest. This gives $0 + \dfrac{1}{2}kx_f^2 = \dfrac{1}{2}(M+m)V^2$, or

$$x_f = V\sqrt{\frac{M+m}{k}} = (1.49\text{ m/s})\sqrt{\frac{2.01\text{ kg}}{19.6\text{ N/m}}} = \boxed{0.478\text{ m}}$$

13.17 The maximum speed occurs at the equilibrium position and is

$$v_{max} = \sqrt{\frac{k}{m}}A \text{ . Thus, } m = \frac{kA^2}{v_{max}^2} = \frac{(16.0 \text{ N/m})(0.200 \text{ m})^2}{(0.400 \text{ m/s})^2} = 4.00 \text{ kg} \text{, and}$$

$$F_g = mg = (4.00 \text{ kg})(9.80 \text{ m/s}^2) = \boxed{39.2 \text{ N}}$$

13.20 (a) $v = \frac{2\pi r}{T} = \frac{2\pi(0.200 \text{ m})}{2.00 \text{ s}} = \boxed{0.628 \text{ m/s}}$

(b) $f = \frac{1}{T} = \frac{1}{2.00 \text{ s}} = \boxed{0.500 \text{ Hz}}$

(c) $\omega = \frac{2\pi}{T} = \frac{2\pi}{2.00 \text{ s}} = \boxed{3.14 \text{ rad/s}}$

13.35 (a) From $T = 2\pi\sqrt{L/g}$, the length of a pendulum with period T is $L = \frac{gT^2}{4\pi^2}$.

On Earth, with $T = 1.0$ s, $L = \frac{(9.80 \text{ m/s}^2)(1.0 \text{ s})^2}{4\pi^2} = 0.25 \text{ m} = \boxed{25 \text{ cm}}$

If $T = 1.0$ s on Mars, $L = \frac{(3.7 \text{ m/s}^2)(1.0 \text{ s})^2}{4\pi^2} = 0.094 \text{ m} = \boxed{9.4 \text{ cm}}$

(b) The period of a mass on a spring is $T = 2\pi\sqrt{m/k}$, which is independent of the local acceleration of gravity. Thus, the same mass will work on Earth and on Mars. This mass is

$$m = \frac{kT^2}{4\pi^2} = \frac{(10 \text{ N/m})(1.0 \text{ s})^2}{4\pi^2} = \boxed{0.25 \text{ kg}}$$

13.37 (a) The amplitude, A, is the maximum displacement from equilibrium. Thus, from Figure P13.37, $A = \frac{1}{2}(18.0\ \text{cm}) = \boxed{9.00\ \text{cm}}$

(b) The wavelength, λ, is the distance between successive crests (or successive troughs). From Figure P13.37, $\lambda = 2(10.0\ \text{cm}) = \boxed{20.0\ \text{cm}}$

(c) The period is $T = \frac{1}{f} = \frac{1}{25.0\ \text{Hz}} = 4.00 \times 10^{-2}\ \text{s} = \boxed{40.0\ \text{ms}}$

(d) The speed of the wave is $v = \lambda f = (0.200\ \text{m})(25.0\ \text{Hz}) = \boxed{5.00\ \text{m/s}}$

13.44 The speed of the wave is $v = \frac{\Delta x}{\Delta t} = \frac{20.0\ \text{m}}{0.800\ \text{s}} = 25.0\ \text{m/s}$, and the mass per unit length of the rope is $\mu = \frac{m}{L} = 0.350\ \text{kg/m}$. Thus, from $v = \sqrt{F/\mu}$, we obtain

$$F = v^2\mu = (25.0\ \text{m/s})^2(0.350\ \text{kg/m}) = \boxed{219\ \text{N}}$$