PHY 2130 Homework solutions
Assignment 12

13.1 (a) The force exerted on the block by the spring is

$$F_s = -kx = -(160\ \text{N/m})(-0.15\ \text{m}) = +24\ \text{N},$$

or $F_s = \boxed{\text{24 N directed toward equilibrium position}}$

(b) From Newton's second law, the acceleration is

$$a = \frac{F_s}{m} = \frac{+24\ \text{N}}{0.40\ \text{kg}} = +60\ \frac{\text{m}}{\text{s}^2} = \boxed{60\ \frac{\text{m}}{\text{s}^2}\ \text{toward equilibrium position}}$$

13.15 From conservation of mechanical energy,

$$\left(KE + PE_g + PE_s\right)_f = \left(KE + PE_g + PE_s\right)_i,$$

we have $\frac{1}{2}mv^2 + 0 + \frac{1}{2}kx^2 = 0 + 0 + \frac{1}{2}kA^2$, or $v = \sqrt{\frac{k}{m}\left(A^2 - x^2\right)}$

(a) The speed is a maximum at the equilibrium position, $x = 0$.

$$v_{max} = \sqrt{\frac{k}{m}A^2} = \sqrt{\frac{(19.6\ \text{N/m})}{(0.40\ \text{kg})}(0.040\ \text{m})^2} = \boxed{0.28\ \text{m/s}}$$

(b) When $x = -0.015\ \text{m}$,

$$v = \sqrt{\frac{(19.6\ \text{N/m})}{(0.40\ \text{kg})}\left[(0.040\ \text{m})^2 - (-0.015\ \text{m})^2\right]} = \boxed{0.26\ \text{m/s}}$$

(c) When $x = +0.015\ \text{m}$,

$$v = \sqrt{\frac{(19.6\ \text{N/m})}{(0.40\ \text{kg})}\left[(0.040\ \text{m})^2 - (+0.015\ \text{m})^2\right]} = \boxed{0.26\ \text{m/s}}$$

(d) If $v = \frac{1}{2} v_{max}$, then $\sqrt{\frac{k}{m}\left(A^2 - x^2\right)} = \frac{1}{2}\sqrt{\frac{k}{m}A^2}$

This gives $A^2 - x^2 = \frac{A^2}{4}$, or $x = A\frac{\sqrt{3}}{2} = (4.0\text{ cm})\frac{\sqrt{3}}{2} = \boxed{3.5\text{ cm}}$

13.22 (a) From, $T = 2\pi\sqrt{\frac{m}{k}}$, we have

$$k = \frac{4\pi^2 m}{T^2} = \frac{4\pi^2(0.200\text{ kg})}{(0.250\text{ s})^2} = \boxed{126\text{ N/m}}$$

(b) At $x = A$, the object is momentarily at rest and

$$E = KE + PE_s = 0 + \frac{1}{2}kA^2$$

Thus, the amplitude is $A = \sqrt{\frac{2E}{k}} = \sqrt{\frac{2(2.00\text{ J})}{126\text{ N/m}}} = 0.178\text{ m} = \boxed{17.8\text{ cm}}$

13.33 (a) The period of the pendulum is $T = 2\pi\sqrt{L/g}$. Thus, on the Moon where the acceleration of gravity is smaller, the period will be longer and the clock will run $\boxed{\text{slow}}$.

(b) The ratio of the pendulum's period on the Moon to that on Earth is

$$\frac{T_{Moon}}{T_{Earth}} = \frac{2\pi\sqrt{L/g_{Moon}}}{2\pi\sqrt{L/g_{Earth}}} = \sqrt{\frac{g_{Earth}}{g_{Moon}}} = \sqrt{\frac{9.80}{1.63}} = 2.45$$

Hence, the pendulum of the clock on Earth makes 2.45 "ticks" while the clock on the Moon is making 1.00 "tick". After the Earth clock has ticked off 24.0 h and again reads 12:00 midnight, the Moon clock will have ticked off $\frac{24.0\text{ h}}{2.45} = 9.79\text{ h}$ and will read $\boxed{9:47\text{ AM}}$.

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 $T = \frac{1}{f} = \frac{1}{25.0\text{ Hz}} = 4.00\times10^{-2}\text{ s} = \boxed{40.0\text{ ms}}$

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

13.38 From $v = \lambda f$, the wavelength (and size of smallest detectable insect) is

$$\lambda = \frac{v}{f} = \frac{340\text{ m/s}}{60.0\times10^{3}\text{ Hz}} = 5.67\times10^{-3}\text{ m} = \boxed{5.67\text{ mm}}$$

13.40 The longest emitted wavelength is $\lambda_{long} = \frac{v}{f_{low}} = \frac{343\text{ m/s}}{28\text{ Hz}} = 12\text{ m}$,

and the shortest is $\lambda_{short} = \frac{v}{f_{high}} = \frac{343\text{ m/s}}{4200\text{ Hz}} = 0.082\text{ m} = 8.2\text{ cm}$

Thus, the range of wavelengths produced is $\boxed{8.2\text{ cm to }12\text{ m}}$

13.45 (a) The mass per unit length is $\mu = \frac{m}{L} = \frac{0.0600\text{ kg}}{5.00\text{ m}} = 0.0120\text{ kg/m}$

From $v = \sqrt{F/\mu}$, the required tension in the string is

$$F = v^2\mu = (50.0\text{ m/s})^2(0.0120\text{ kg/m}) = \boxed{30.0\text{ N}},$$

(b) $v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{8.00\text{ N}}{0.0120\text{ kg/m}}} = \boxed{25.8\text{ m/s}}$