Q2. A given force will move the middle of the spring half as far as the end, so if the spring were cut there, \( k' \left( \frac{1}{2} \Delta x \right) = k \Delta x \), so \( k' = 2k \).

Q3. At the turning points (where \( v = 0 \)) \( E_T = PE \), or \( E_T = \frac{1}{2} k x^2 \). This is independent of the mass! Since the PE, for any \( x \), is independent of mass (and \( PE + KE = constant \)), \( KE \) will at any \( x \) also be independent of mass.

What actually happens is that if the mass is larger, the speed of the motion is less — enough less to yield the same kinetic energy.

P2 (a) \( F = -W \), \( \Delta x = 5.0 \text{ cm} = 0.050 \text{ m} \), \( W = 50 \text{ N} \).

\[
F = -k \Delta x, \quad k = \frac{50 \text{ N}}{0.050 \text{ m}} = 1000 \text{ N/m}
\]

\[
\Delta x \uparrow F
\]

\[\downarrow W \quad \text{If} \quad \Delta x = 11 \text{ cm} = 0.11 \text{ m},
\]

\[
F = (1000 \text{ N/m})(0.11 \text{ m}) = 110 \text{ N}
\]
P3. \[ v_0 = 0 \text{ m/s} \]

(a) Because the collision is elastic (and the ground is part of an infinite-mass object) the magnitude of \( v \) must remain the same — its direction is reversed by the collision. That means all the kinetic energy gained on falling will be lost as the ball rises, zero kinetic energy corresponds to the original height. This process repeats indefinitely, each time requiring the same \( \Delta t \).

(b) The period is the time to fall & rise again, which is \( 2t \) the time to fall. The collision is assumed to take negligible time. \( \Delta y = \frac{1}{2} at^2 = \frac{1}{2} g t^2 \),
\[
t = \sqrt{\frac{2 \Delta y}{g}}, \quad T = 2t = 2 \sqrt{\frac{2 \Delta y}{g}} = 2 \left( \frac{2 \times 4.00 \text{ m}}{9.80 \text{ m/s}^2} \right) \]
\[
= 1.81 \text{ s}
\]

(c) Motion is not simple harmonic because the force involved does not depend linearly on position. (Gravity exerts a force that is independent of position.)
PH.

\[ K = 65.0 \text{ N/m} \text{ each spring,} \]

\[ F = K \Delta x \text{ each spring,} \]

so, together \[ E = -4K \Delta x = -K \Delta x \]

\[ K = 4 \times 65 = 260 \text{ N/m}. \]

\[ \Delta x = (80.0 - 43.5) \text{ cm} = 36.5 \text{ cm} = 0.365 \text{ m}. \]

\[ F_H = -E = +K \Delta x = (260 \text{ N/m})(0.365 \text{ m}) = 94.9 \text{ N}. \]

P6 (a)

\[ k = 5.60 \times 10^6 \text{ N/m}, \]

\[ T = 210 \text{ N}, \]

\[ \theta = 32.5^\circ. \]

\[ \Sigma F = 0 = T \cos \theta - T \cos \theta. \]

Trivial, not helpful.

\[ \Sigma F_y = 0 \]

\[ 2(210 \text{ N}) - k \Delta y = 0 \]

\[ \Delta y = \frac{2(210 \text{ N}) \sin 32.5^\circ}{5.60 \times 10^6 \text{ N/m}} \]

\[ = 4.03 \times 10^{-3} \text{ m} = 4.03 \text{ mm}. \]
\[ F_s = 2kA = KA \ (K = 2k) \]

But we need to get \( k \).

From \( F = 15 \text{ N} \) when \( \Delta x = 1 \text{ cm} \):

\[ k = \frac{F}{\Delta x} = \frac{15 \text{ N}}{0.01 \text{ m}} = 1500 \text{ N/m} \]

(a) \( \text{PE} = \frac{1}{2} kA^2 = \frac{1}{2} (2k) A^2 = kA^2 = (1500 \text{ N/m}) (0.20 \text{ m})^2 = 60 \text{ J} \)

(b) \( \text{KE_{final}} = \text{PE}_{elastic} \Rightarrow \frac{1}{2} m v^2 = \text{PE} \)

\[ v^2 = \frac{2 \text{ PE}}{m} \]

\[ v = \sqrt{\frac{2 \text{ PE}}{m}} = \sqrt{\frac{2(60 \text{ J})}{0.050 \text{ kg}}} = 49.0 \text{ m/s} \]

P14.

(a) Use work-energy concept. \[ (\text{KE})_{x=0} = (\text{PE})_{x=A} \]

\[ \frac{1}{2} m v^2 = \frac{1}{2} kA^2 \rightarrow v^2 = \frac{kA^2}{m} \rightarrow v = \sqrt{\frac{k}{m} A^2} \]

\[ v = \sqrt{\frac{2.0 \times 10^3 \text{ N/m}}{1.5 \text{ kg}}} \left(3.0 \times 10^{-3} \text{ m} \right) = 0.11 \text{ m/s} = \boxed{11 \text{ cm/s}} \]
(b) \[ \text{Now } (KE)_{x=0} = (PE)_{x=A} + W_f \quad F_f = 2.0 \text{ N} \]

\[
W_f = -F_f d = -F_f A = -(2.0 \text{ N})(3.0 \times 10^{-3} \text{ m}) = 6 \times 10^{-3} \text{ J}
\]

\[
\frac{1}{2} mv^2 = \frac{1}{2} kA^2 + W_f
\]

\[
v^2 = \frac{kA^2 + 2W_f}{m} = \sqrt{\frac{(2.30 \times 10^3 \text{ N/m})(3.0 \times 10^{-3} \text{ m})^2 + 2(-6 \times 10^{-3} \text{ J})}{1.5 \text{ kg}}}
\]

\[
v = 0.063 \text{ m/s} = 0.063 \text{ cm/s}
\]

(c) \[ \text{Null } v^2 = 0 \quad \text{or} \quad \frac{1}{2} kA^2 + W_f = 0 \quad \text{or} \quad \frac{1}{2} kA^2 = F_f A \quad \text{or} \quad F_f = \frac{1}{2} kA = \frac{1}{2} \left( \frac{2.00 \times 10^3 \text{ N/m}}{3.0 \times 10^{-3} \text{ m}} \right) = 3.0 \text{ N} \]
P16. \[ k = \frac{m}{x} \quad A = 3.5 \text{m} = 0.035 \text{m} \]
\[ k = 250 \text{ N/m} \]
\[ m = 0.50 \text{ kg} \]

(a) Calculate total energy at \( x = A \), where KE = 0
\[ PE = \frac{1}{2} kA^2 = \frac{1}{2} (250 \text{ N/m}) (0.035 \text{ m})^2 = 1.015 \text{ J} \]

(b) Max v when PE = 0, i.e. when \( x = 0 \).

Then \[ \frac{1}{2} mv^2 = \frac{1}{2} kA^2 \Rightarrow v^2 = \frac{kA^2}{m} \Rightarrow v = \sqrt{\frac{kA^2}{m}} \]

\[ v = \sqrt{\frac{250 \text{ N/m}}{0.50 \text{ kg}} (0.035 \text{ m})} = 0.78 \text{ m/s} \]

(c) Max a when F is largest, thus is at A, \( F = -kA \)
\[ F = ma = -kA \quad a = -\frac{kA}{m} \quad (\text{for } A > x > 0) \]

Another place of same \( |a| \) is at \( x = -A \).
\[ |a| = \frac{kA}{m} = \frac{(250 \text{ N/m})(0.035 \text{ m})}{0.50 \text{ kg}} = 17.5 \text{ m/s}^2 \]