1) A spring lies on a horizontal table, and the left end of the spring is attached to a wall. The other end is connected to a box. The box is pulled to the right, stretching the spring. Static friction exists between the box and the table so when the spring is stretched only by a small amount, the box does not move. The mass of the box is 0.80 kg, and the spring has a constant of 59 N/m. The coefficient of static friction between the box and the table on which it rests is \( \mu_s = 0.74 \). How far can the spring be stretched from its unstrained position without the box moving when released?

2) When responding to sound, the human ear drum vibrates about its equilibrium position. Suppose an eardrum is vibrating with an amplitude of \( 6.3 \times 10^{-7} \) m and a maximum speed of \( 2.9 \times 10^{-3} \) m/s. a) what is the frequency (in Hertz) of the eardrum’s vibration? b) What is the maximum acceleration of the eardrum?

3) A heavy duty stapling gun uses a 0.140 kg metal rod that rams against the staple to eject it. The rod is attached to and pushed by a stiff spring called a “ram spring” \( k = 32000 \) N/m. The mass of the spring may be ignored. The ram spring is compressed by \( 3.0 \times 10^{-2} \) m from its unstrained length and then released from rest. Assuming that the ram spring is oriented vertically and is still compressed by \( 0.8 \times 10^{-3} \) m when the downward moving ram hits the staple, find the speed of the ram at the instant of contact.

4) A simple pendulum is swinging back and forth through a small angle, its motion repeating every 1.25 s. How much longer should the pendulum be made in order to increase its period by 0.20 s?

\[
\begin{align*}
\mu mg &= kx \\
x &= \frac{\mu mg}{k} \\
x &= \frac{(0.74)(0.80 \text{ kg})}{59 \text{ N/m}} \\
&= 0.098 \text{ m}
\end{align*}
\]
4) \[ \omega^2 = \frac{g}{\ell} \]

\[ \omega = 2\pi f = \frac{2\pi}{T} \]

\[ \Rightarrow T = \frac{2\pi}{\omega} \]

\[ \frac{2\pi}{T} = \sqrt{\frac{g}{\ell}} \]

\[ T = 2\pi \sqrt{\frac{\ell}{g}} \]

\[ T_0 = 1.25 \text{ s} = 2\pi \sqrt{\frac{\ell_0}{g}} \]

\[ T_0^2 = \frac{4\pi^2}{g} \frac{\ell_0}{g} \Rightarrow \ell_0 = \left( \frac{T_0}{2\pi} \right)^2 \frac{g}{9} \]

\[ \ell_0 = \left( \frac{1.25}{2\pi} \right)^2 9.8 \]

\[ \ell_0 = 0.388 \text{ m} \]

\[ T_1 = 1.45 \text{ s} \]

\[ \ell_1 = \left( \frac{1.45}{2\pi} \right)^2 9.8 \]

\[ \ell_1 = 0.522 \text{ m} \]

\[ \Delta \ell = \ell_1 - \ell_0 = 0.134 \text{ m} \]
\[ a_{\text{max}} = \omega^2 A \]

\[ = (4.603)^2 \left( 6.3 \times 10^{-7} \right) = \overline{13.3 \text{ m/s}^2} \]

3) \[ k = 32000 \text{ N/m} \]

\[ m = 0.14 \text{ kg} \]

\[ E = \frac{1}{2} mv^2 + mg \frac{h}{2} + \frac{1}{2} klx^2 = \text{const.} \]

\[ E_0 = 0 + (0.14 \text{ kg})(9.8 \text{ m/s}^2)(3 \times 10^{-2} \text{ m}) + \frac{1}{2}(32000 \text{ N/m})(3 \times 10^{-2} \text{ m})^2 \]

\[ = 0.04116 \overline{J} + 14.4 \overline{J} \]

\[ E_0 = 14.44 \overline{J} \]

\[ E_f = \frac{1}{2} mv^2 + (mg \frac{h}{2}) + \frac{1}{2} klx^2 \]

\[ = \frac{1}{2} mv^2 + (0.14)(9.8)(0.8 \times 10^{-2}) + \frac{1}{2}(32000)(0.8 \times 10^{-2})^2 \]

\[ = \frac{1}{2} mv^2 + 0.011 \overline{J} + 1.024 \overline{J} \]

\[ = \frac{1}{2} mv^2 + 1.04 \overline{J} \]

Now \[ \frac{1}{2} mv^2 + 1.04 \overline{J} = 14.44 \overline{J} \]

\[ \frac{1}{2} mv^2 = 13.4 \overline{J} \]

\[ v = \sqrt{\frac{2(13.4)}{0.14}} = \overline{13.8 \text{ m/s}} \]