Q 21

Since a pendulum experiences air resistance, it will lose mechanical energy and eventually stop swinging.

Q 23

a) The work in stretching the spring goes into elastic potential energy.

b) The potential energy is greatest when the kinetic energy is the least. This happens at each end of oscillation when the body comes to rest instantaneously and the spring is compressed or stretched by the maximum amount.

Q 25

Increased. There are two potential energy contributions. As the mass is lowered, the gravitational energy decreases while the elastic energy of the spring increases \( (\sim x^2) \). The net potential energy increases.
14.1

\[ f' = 2f_o \]

\[ \frac{m'}{m_o} \]

\[ T = 2\pi \sqrt{\frac{g}{g}} \quad \text{does not depend on mass} \]

Spring pendulum: \[ T = 2\pi \sqrt{\frac{m}{k}} \]

\[ f_o = \frac{1}{T} = \frac{1}{2\pi} \sqrt{\frac{k}{m_o}}; \quad f' = \frac{1}{2\pi} \sqrt{\frac{k}{m'}} \]

\[ \frac{f'}{f_o} = \sqrt{\frac{m_o}{m'}} = 2 \quad \Rightarrow \quad \frac{m'}{m_o} = 1 \]

14.4

\[ k = 100 \frac{N}{m} \]

\[ m = 8 \text{ g} \]

\[ \Delta x = 5 \text{ cm} \]

\[ \theta_0 = ? \]

Before

\[ \hbar_c \text{ or } \hbar_c \leftrightarrow \hbar_c \]

After

\[ \hbar_m \rightarrow \hbar_m \quad \theta_0 \]

\[ \frac{k\Delta x^2}{2} = \frac{m\theta_0^2}{2} \]

\[ \theta_0 = \sqrt{\frac{k}{m} \Delta x^2} = 5.6 \text{ m/s} \]
14.8

\[ T_1 = 0.3 \, \text{s} \]
\[ W_1 = 30 \, \text{N} \]
\[ W_2 = 50 \, \text{N} \]

\( \Delta x = ? \)

\[ T_1 = 2\pi \sqrt{\frac{m_1}{k}} = 2\pi \sqrt{\frac{W_1}{g}} \]

\[ T_1^2 = \frac{W_1}{4a^2} \]

\[ k = \frac{4a^2 W_1}{T_1^2 g} \]

\[ \Delta x = \frac{W_2}{k} = \frac{W_2}{W_1} \cdot \frac{T_1^2}{4a^2} \cdot g \approx 0.04 \, \text{m} \]

14.16

\[ l = 20 \, \text{ft} \]

\[ T = ? \]

\[ T = 2\pi \sqrt{\frac{I}{mg}} \]

\[ I = \frac{1}{3} ml^2, \quad h = \frac{l}{2} \]

\[ T = 2\pi \sqrt{\frac{ml^2/2}{3mg}} = 2\pi \sqrt{\frac{2l}{3g}} = 4 \, \text{s} \]
14.18

\[ I = 0.5 \, \text{kg} \cdot \text{m}^2 \]

\[ f = 2 \, \text{Hz} \]

\[ k = 4\pi f^2 I = 7.8 \, \text{N} \cdot \text{m}^{-1} \]

14.10

\[ A = 1 \, \text{cm} \]

\[ T = 0.2 \, \text{s} \]

\[ x_0 = 0.3 \, \text{cm} \]

\[ a = ? \]

\[ x = A \sin \omega t \]

\[ \varphi = A \omega \cos \omega t = A \omega \sqrt{1 - \sin^2 \omega t} \]

\[ a = -A \omega^2 \sin \omega t \]

\[ \omega = \frac{2\pi}{T} = 31.4 \, \text{Hz} \]

\[ a(t) = x_0 \frac{A}{A} \sin \omega t, \quad S \sin \omega t_0 = \frac{x_0}{A} = 0.3 \]

\[ \varphi = A \omega \cos \omega t = A \omega \sqrt{1 - \sin^2 \omega t_0} = 30 \, \text{cm} \]

\[ 1_{x=x_0} = A^{2} \]

\[ Q_{x=x_0} = -A \omega^2 \sin \omega t_0 = -A \left( \frac{2\pi}{T} \right)^2 \frac{x_0}{A} = \frac{-296 \, \text{cm} \cdot \text{s}^{-2}}{\text{s}^2} = -296 \, \text{cm/s}^2 \]