2. ***REASONING*** The weight of the person causes the spring in the scale to compress. The amount $x$ of compression, according to Equation 10.1, depends on the magnitude $F_{\text{Applied}}$ of the applied force and the spring constant $k$.

***SOLUTION***
a. Since the applied force is equal to the person's weight, the spring constant is

$$k = \frac{F_{\text{Applied}}}{x} = \frac{670\ \text{N}}{0.79 \times 10^{-2}\ \text{m}} = \boxed{8.5 \times 10^{4}\ \text{N/m}} \qquad (10.1)$$

b. When another person steps on the scale, it compresses by 0.34 cm. The weight (or applied force) that this person exerts on the scale is

$$F_{\text{Applied}} = kx = \left(8.5 \times 10^{4}\ \text{N/m}\right)\left(0.34 \times 10^{-2}\ \text{m}\right) = \boxed{290\ \text{N}} \qquad (10.1)$$

20. ***REASONING AND SOLUTION*** For mass 1 we have

$$f_1 = \frac{1}{2\pi}\sqrt{\frac{k}{m_1}} \qquad (10.11)$$

For mass 2 we have

$$f_2 = \frac{1}{2\pi}\sqrt{\frac{k}{m_1 + m_2}}$$

Therefore,

$$\frac{f_1}{f_2} = \sqrt{\frac{m_1 + m_2}{m_1}} = 3.00$$

Squaring and solving yields

$$\frac{m_1 + m_2}{m_1} = 9.00 \quad \text{or} \quad m_1 + m_2 = 9.00\ m_1$$

Solving for the ratio $m_2/m_1$ gives $m_1/m_2 = \boxed{8.00}$.

22. ***REASONING AND SOLUTION***

a. $x = A\cos\omega t$ where $\omega = 2\pi f = 4\pi$ rad/s

$$x = (0.500\text{ m})\cos[(4\pi\text{ rad/s})(0.0500\text{ s})] = \boxed{0.405\text{ m}} \qquad (10.3)$$

b. $v = -A\omega\sin\omega t$

$$v = -(0.500\text{ m})(4\pi\text{ rad/s})\sin[(4\pi\text{ rad/s})(0.0500\text{ s})] = -3.69\text{ m/s} \qquad (10.7)$$

The magnitude of v is $\boxed{3.69\text{ m/s}}$

c. $a = -A\omega^2\cos\omega t$

$$a = -(0.500\text{ m})(4\pi\text{ rad/s})^2\cos[(4\pi\text{ rad/s})(0.0500\text{ s})] = -63.9\text{ m/s}^2 \qquad (10.9)$$

The magnitude of a is $\boxed{63.9\text{ m/s}^2}$

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25. SSM ***REASONING*** The only force that acts on the block along the line of motion is the force due to the spring. Since the force due to the spring is a conservative force, the principle of conservation of mechanical energy applies. Initially, when the spring is unstrained, all of the mechanical energy is kinetic energy, $(1/2)mv_0^2$. When the spring is fully compressed, all of the mechanical energy is in the form of elastic potential energy, $(1/2)kx_{max}^2$, where $x_{max}$, the maximum compression of the spring, is the amplitude $A$. Therefore, the statement of energy conservation can be written as

$$\tfrac{1}{2}mv_0^2 = \tfrac{1}{2}kA^2$$

This expression may be solved for the amplitude $A$.

***SOLUTION*** Solving for the amplitude $A$, we obtain

$$A = \sqrt{\frac{mv_0^2}{k}} = \sqrt{\frac{(1.00\times10^{-2}\text{ kg})(8.00\text{ m/s})^2}{124\text{ N/m}}} = \boxed{7.18\times10^{-2}\text{ m}}$$

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27. ***REASONING AND SOLUTION*** Assuming that mechanical energy is conserved

$$(1/2)\,kx_0^2 = (1/2)\,mv_f^2 + mgh_f$$

or

$$v_f = \sqrt{\frac{kx_0^2}{m} - 2gh_f} = \sqrt{\frac{(675\text{ N/m})(0.0650\text{ m})^2}{0.0585\text{ kg}} - 2(9.80\text{ m/s}^2)(0.300\text{ m})} = \boxed{6.55\text{ m/s}}$$

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33. **SSM** ***REASONING AND SOLUTION*** The amount by which the spring stretches due to the weight of the 1.1-kg object can be calculated using Equation 10.1, where the force $F$ is equal to the weight of the object. The position of the object when the spring is stretched is the equilibrium position for the vertical harmonic motion of the object-spring system.

a. Solving Equation 10.1 for $x$ with $F$ equal to the weight of the object gives

$$x = \frac{F}{k} = \frac{mg}{k} = \frac{(1.1\text{ kg})(9.80\text{ m/s}^2)}{120\text{ N/m}} = \boxed{9.0 \times 10^{-2}\text{ m}}$$

b. The object is then pulled down another 0.20 m and released from rest ($v_0 = 0$ m/s). At this point the spring is stretched by an amount of $0.090\text{ m} + 0.20\text{ m} = 0.29\text{ m}$. We will let this point be the zero reference level ($h = 0$ m) for the gravitational potential energy.

The kinetic energy, the gravitational potential energy, and the elastic potential energy at the point of release are:

$$\text{KE} = \tfrac{1}{2}mv_0^2 = \tfrac{1}{2}m(0\text{ m/s})^2 = 0\text{ J}$$

$$\text{PE}_{\text{gravity}} = mgh = mg(0\text{ m}) = 0\text{ J}$$

$$\text{PE}_{\text{elastic}} = \frac{1}{2}kx_0^2 = \frac{1}{2}(120\text{ N/m})(0.29\text{ m})^2 = 5.0\text{ J}$$

The total mechanical energy $E_0$ is the sum of these three energies, so $E_0 = 5.0$ J. When the object has risen a distance of $h = 0.20$ m above the release point, the spring is stretched by an amount of $0.29\text{ m} - 0.20\text{ m} = 0.090\text{ m}$. Since the total mechanical energy is conserved, its value at this point is still 5.0 J. Thus,

$$E = \text{KE} + \text{PE}_{\text{gravity}} + \text{PE}_{\text{elastic}}$$

$$E = \frac{1}{2}mv^2 + mgh + \frac{1}{2}kx^2$$

$$5.0\text{ J} = \frac{1}{2}(1.1\text{ kg})v^2 + (1.1\text{ kg})(9.80\text{ m/s}^2)(0.20\text{ m}) + \frac{1}{2}(120\text{ N/m})(0.090\text{ m})^2$$

Solving for $v$ yields $v = \boxed{2.1\text{ m/s}}$.

36. ***REASONING AND SOLUTION*** Use conservation of energy to find the speed of point A (take the pivot to have zero gravitational PE).

$$E_{up} = mgh = E_{down} = (1/2)\ I\omega^2 + (1/2)\ kx^2$$

where the moment of inertia of the bar is $I = (1/3)mL^2$, L = bar length and $\omega = v/L$. Substituting these into the energy equation and solving for v (Note that x = 0.224 m − 0.100 m = 0.124 m and that h = L/2 from the diagram),

$$v = \sqrt{\frac{3\left(mgL - kx^2\right)}{m}} = \sqrt{\frac{3\left[(0.750\ \text{kg})(9.80\ \text{m/s}^2)(0.200\ \text{m}) - (25.0\ \text{N/m})(0.124\ \text{m})^2\right]}{0.750\ \text{kg}}} = \boxed{2.08\ \text{m/s}}$$

39. ***REASONING AND SOLUTION*** Applying Equation 10.16 and recalling that frequency and period are related by f = 1/T,

$$2\pi f = \frac{2\pi}{T} = \sqrt{\frac{g}{L}}$$

where L is the length of the pendulum. Thus,

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Solving for L gives

$$L = g\left(\frac{T}{2\pi}\right)^2 = \left(9.80\ \text{m/s}^2\right)\left(\frac{9.2\ \text{s}}{2\pi}\right)^2 = \boxed{21\ \text{m}}$$

40. ***REASONING AND SOLUTION*** The period of a simple pendulum is given by

$$T = 2\pi\sqrt{\frac{L}{g}}$$

The gravitational acceleration changes, but we want the period to remain the same, therefore we can write

$$2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{L'}{g'}}$$

Squaring each side of the equation and solving for L', the new length, we obtain

$$L' = L(g'/g) = (1.00\ \text{m})(9.78\ \text{m/s}^2)/(9.83\ \text{m/s}^2) = \boxed{0.995\ \text{m}}$$