13.5 (a) At $t = 0$, $x = 0$ and v is positive (to the right). Therefore, this situation corresponds to

$$x = A \sin \omega t \quad \text{and} \quad v = v_i \cos \omega t$$

Since $f = 1.50$ Hz, $\omega = 2\pi f = 3.00\pi$

Also, $A = 2.00$ cm, so that $\boxed{x = (2.00 \text{ cm}) \sin 3.00\pi t}$

(b) $v_{max} = v_i = A\omega = (2.00)(3.00\pi) = \boxed{6.00\pi \text{ cm/s}}$

The particle has this speed at $t = 0$ and next at $t = \dfrac{T}{2} = \boxed{\dfrac{1}{3} \text{ s}}$

(c) $a_{max} = A\omega^2 = 2(3.00\pi)^2 = \boxed{18.0\pi^2 \text{ cm/s}^2}$

The acceleration has this positive value for the first time at

$$t = \frac{3T}{4} = \boxed{0.500 \text{ s}}$$

(d) Since $T = \dfrac{2}{3}$ s and $A = 2.00$ cm, the particle will travel 8.00 cm in this time.

Hence, in $1.00 \text{ s} \left(= \dfrac{3T}{2}\right)$, the particle will travel

$$8.00 \text{ cm} + 4.00 \text{ cm} = \boxed{12.0 \text{ cm}}$$

13.7 $k = \dfrac{F}{x} = \dfrac{(10.0 \times 10^{-3} \text{ kg})(9.80 \text{ m/s}^2)}{3.90 \times 10^{-2} \text{ m}} = 2.51 \text{ N/m}$ and

$$T = 2\pi \sqrt{\frac{m}{k}} = 2\pi \sqrt{\frac{25.0 \times 10^{-3} \text{ kg}}{2.51 \text{ N/m}}} = \boxed{0.627 \text{ s}}$$

13.10 $m = 1.00$ kg, $k = 25.0$ N/m, and $A = 3.00$ cm

At $t = 0$, $x = -3.00$ cm

(a) $\omega = \sqrt{\dfrac{k}{m}} = \sqrt{\dfrac{25.0}{1.00}} = 5.00 \text{ rad/s}$

so that, $T = \dfrac{2\pi}{\omega} = \dfrac{2\pi}{5.00} = \boxed{1.26 \text{ s}}$

(b) $v_{max} = A\omega = (3.00 \times 10^{-2} \text{ m})(5.00 \text{ rad/s}) = \boxed{0.150 \text{ m/s}}$

$a_{max} = A\omega^2 = (3.00 \times 10^{-2} \text{ m})(5.00 \text{ rad/s})^2 = \boxed{0.750 \text{ m/s}^2}$

(c) Because $x = -3.00$ cm and $v = 0$ at $t = 0$, the required solution is

$$x = -A \cos \omega t$$

or $\boxed{x = -3.00 \cos (5.00t) \text{ cm}}$

$$v = \frac{dx}{dt} = \boxed{15.0 \sin (5.00t) \text{ cm/s}}$$

$$a = \frac{dv}{dt} = \boxed{75.0 \cos (5.00t) \text{ cm/s}^2}$$

13.17 By conservation of energy, $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$$v = \sqrt{\frac{k}{m}}\,x = \sqrt{\frac{5.00 \times 10^6}{10^3}}\,(3.16 \times 10^{-2}\text{ m}) = \boxed{2.23\text{ m/s}}$$

13.22 (a) $E = \frac{1}{2}kA^2$, so if $A' = 2A$, $E' = \frac{1}{2}k(A')^2 = \frac{1}{2}k(2A)^2 = 4E$

Therefore $\boxed{E\text{ increases by factor of }4}$.

(b) $v_{\max} = \sqrt{\frac{k}{m}}\,A$, so if A is doubled, $\boxed{v_{\max}\text{ is doubled}}$.

(c) $a_{\max} = \frac{k}{m}A$, so if A is doubled, $\boxed{a_{\max}\text{ also doubles}}$.

(d) $T = 2\pi\sqrt{\frac{m}{k}}$ is independent of A, so $\boxed{\text{the period is unchanged}}$.

***13.27** The swinging box is a physical pendulum with period $T = 2\pi\sqrt{\frac{I}{mgd}}$.

The moment of inertia is given approximately by

$I = \frac{1}{3}mL^2$ (treating the box as a rod suspended from one end).

Then, with $L \approx 1.0$ m and $d \approx L/2$,

$$T \approx 2\pi\sqrt{\frac{(1/3)mL^2}{mg(L/2)}} = 2\pi\sqrt{\frac{2L}{3g}} = 2\pi\sqrt{\frac{2(1.0\text{ m})}{3(9.8\text{ m/s}^2)}} = 1.6\text{ s} \quad \text{or} \quad T \sim \boxed{10^0\text{ s}}$$

13.49 Assume that each spring supports an equal portion of the car's mass, i.e. $\frac{m}{4}$.

Then $T = 2\pi\sqrt{\frac{m}{4k}}$ and $k = \frac{4\pi^2 m}{4T^2} = \frac{4\pi^2 1500}{(4)(1.50)^2} = \boxed{6580\text{ N/m}}$