A. 1. From $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$

   a. $f$ goes down by a factor of $\sqrt{2}$
   b. no effect.

2. a. 12 s. The wave has gone through one complete cycle between the pictures, returning to how the water looked at the start. So, the time between pictures is the period.
   b. $f = 1/T = 1/12 = .0833$ Hz
   c. $\omega = 2\pi f = 2\pi(.0833) = .524$ rad/s
   d. Read the distance between crests from the graph: 30.0 m
   e. $v = f\lambda = (.0833)(30.0) = 2.50$ m/s

B. 1. $T = 1/f = 1/5 = .200$ s

2. a. The distance from one crest to the next is the wavelength: $\lambda = 4.00$ cm.
   \[ f = \frac{v}{\lambda} = \frac{5 \text{ m/s}}{(.04 \text{ m})} = 125 \text{ Hz} \]
   b. 0.10 mm directly off the graph.
   c. $\lambda = \frac{v}{f} = \frac{5 \text{ m/s}}{250 \text{ Hz}} = .020$ m (Or, just notice that $\lambda$ is inversely proportional to $f$, so double the $f$ means half the $\lambda$.)

C. 1. **Transverse:** The medium is displaced perpendicular to the direction of propagation.
   **Longitudinal:** The medium is displaced parallel to the direction of propagation.
2. 

\[ f = \text{frequency} \]
\[ F = \text{force (string tension)} \]
\[ f = \frac{1}{T} = \frac{1}{.111s} = 9.09 \text{ Hz} \]
\[ \mu = \frac{\text{mass}}{\text{length}} = \frac{.500 \text{ kg}}{2.00 \text{ m}} = .25 \text{ kg/m} \]
\[ \lambda = \frac{v}{f} = \frac{(2.998 \times 10^8 \text{ m/s})}{(6.328 \times 10^{-7} \text{ m})} = 4.74 \times 10^{14} \text{ Hz} \]

3. From formula sheet: 
\[ f = \frac{1}{2\pi} \sqrt{\frac{k}{m}} \]
Since \( T = 1/f \), 
\[ T = 2\pi \sqrt{\frac{m}{k}} \]

\[ T_2 = 2\pi \sqrt{\frac{6.50}{100}} = 1.6019s \]
\[ T_1 = 2\pi \sqrt{\frac{6.00}{100}} = 1.5391s \]

Difference = \( .0628 \) s

D. 1. Because of friction. (A truly frictionless oscillator would go forever.)

2. \( f = \frac{v}{\lambda} = \frac{(2.998 \times 10^8 \text{ m/s})}{(6.328 \times 10^{-7} \text{ m})} = 4.74 \times 10^{14} \text{ Hz} \)
(Get speed of light from formula sheet.)

3. From formula sheet:
\[ f = \frac{1}{2\pi} \sqrt{\frac{k}{m}} \]

E. 1. A little sooner in the summer. From \( v = \sqrt{4027} \), the speed of sound in air goes up with temperature.

2. Sooner on the light rope. Speed of string waves:
\[ v = \sqrt{\frac{F}{\mu}} \]

3. From Hooke’s law, \( k = F/x \). (If you don’t need to keep track of directions, take the absolute value of both sides of Hooke’s law to get rid of its minus sign. There is no such thing as a negative spring constant.)
\[ k = \frac{(1.96 \text{ N})}{(.22 \text{ m})} = 8.91 \text{ N/m} \]
\[ f = \frac{1}{2\pi} \sqrt{\frac{k}{m}} = \frac{1}{2\pi} \sqrt{\frac{8.91 \text{ N/m}}{.200 \text{ kg}}} = 1.06 \text{ Hz} \]