$\boxed{16.2}$

Ten cycles of waves are completed in 120 s. Because frequency is the number of cycles that occur divided by the time required for their completion,

$$f = \frac{10\ \text{cycles}}{120\ \text{s}} = \frac{1}{12}\ \text{cycle/s} = \frac{1}{12}\ \text{Hz} = \boxed{.083\ \text{Hz.}}$$

$\boxed{16.3}$

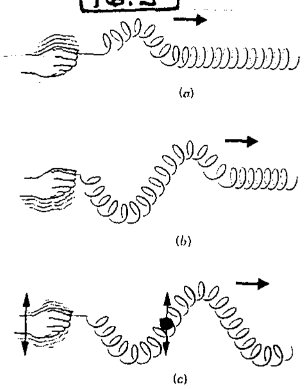
$f = 3.0\,\text{Hz.}$
$t = 1.7\,\text{s.}$
$s = 2.5\,\text{m.}$
$\lambda = ?$

Since $s = v_{ave} t \longrightarrow v_{ave} = \frac{s}{t} = \frac{2.5\,\text{m}}{1.7\,\text{s.}} = 1.471\,\text{m/s.}$

Since $v = \lambda f \longrightarrow \lambda = \frac{v}{f} = \frac{1.471\,\text{m/s.}}{3.0\,\text{cycles/s.}} = 0.4902\,\text{m/cycle.}$

Rounded to two significant figures, $\lambda = \boxed{0.49\,\text{m}}$

$\boxed{16.5}$



Since "the hand moves the end of the Slinky up and down through two complete cycles in one second", the frequency is

$$f = 2 \text{ cycles/s} \quad (\text{or } 2 \text{ Hz})$$

And since $v = 0.50 \text{ m/s}$,

$$\lambda = \frac{v}{f} = \frac{0.50 \text{ m/s}}{2 \text{ cycles/s}} = \boxed{0.25 \text{ m/cycle}}$$

16.13

$F = 944\ N.$

$T = 3.82 \times 10^{-3}\ s/cycle$

$\lambda = 1.26\ m/cycle$

$m/\ell = ?$ (the "linear density")

Linear density and force are terms found in the equation for the speed of propagation of a transverse wave,

$$v = \sqrt{\frac{F}{m/\ell}} \quad \#1$$

Squaring both sides of eq#1 and solving for the linear density,

$$m/\ell = \frac{F}{v^2} \quad \#2$$

According to eq#2, we will need v, the speed of propagation. We can find v using

$$v = f\lambda \quad \text{and} \quad f = \frac{1}{T}.$$

$$v = \frac{\lambda}{T} = \frac{1.26\ m/cycle}{3.82 \times 10^{-3}\ s/cycle} = 329.8429319\ m/s.$$

Substituting this value into eq#2

$$m/\ell = \frac{944\ N}{(329.8429319\ m/s)^2} = 0.008676709\ kg/m.$$

Rounded to three significant figures,

$$m/\ell = \boxed{0.00868\ kg/m}$$

$\boxed{16.32}$

$Y_{steel} = 2.0 \times 10^{11}\ N/m^2$
$\rho_{steel} = 7860\ kg/m^3$

$$\therefore\ v_{steel} = \sqrt{\frac{Y_{steel}}{\rho_{steel}}} = \sqrt{\frac{2.0 \times 10^{11}\ N/m^2}{7860\ kg/m^3}} = 5044.33\ m/s.$$

From table #1 in this chapter, the speed of sound in air at 20°C is

$v_{air} = 343\ m/s.$

Therefore the speed of sound in steel compared its speed in air is given by the ratio

$$\frac{v_{steel}}{v_{air}} = \frac{5044.33\ m/s}{343\ m/s} = 14.7065$$

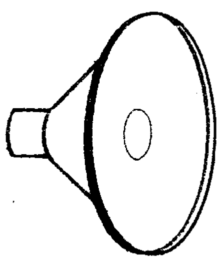
Rounded to two significant figures, sound travels $\boxed{15}$ times faster in steel than it does in air.

$\boxed{16.48}$

$A = 2.1 \times 10^{-3} m^2$
$I = 3.2 \times 10^{-6} W/m^2$
$P = ?$

Since $I = \frac{P}{A} \longrightarrow P = IA = (3.2 \times 10^{-6} W/m^2)(2.1 \times 10^{-3} m^2) = \boxed{6.7 \times 10^{-9} W.}$

$\boxed{16.53}$



$r = 0.0950\,m.$
$P_E = 25.0\,W.$ (electric power)
$I_s = 17.5\ W/m^2$ (actual sound intensity produced by speaker)
% converted to sound = ?

To determine the percentage of the electric power P_E converted into acoustic (or sound) power P_s, we must first calculate P_s:

Since $I = P/A \longrightarrow P = IA$; and with $A = \pi r^2$

$$P_s = I_s \pi r^2 = (17.5\ W/m^2)\,\pi\,(0.0950\,m)^2 = 0.4961752\ W.$$

Now the ratio P_s/P_E is the fraction of the electric power that is converted to sound; and when multiplied by 100, it is the percentage:

$$\left(\frac{P_s}{P_E}\right)100 = \left(\frac{0.4961752\,W}{25.\,W}\right)100 = \boxed{1.98\ \%}$$

$\boxed{16.72}$

The Doppler Effect equation for a source moving toward the observer and the observer moving toward the source is

$$f_o = f_s\left(\frac{v + v_o}{v - v_s}\right)$$

$$\therefore\ f_o = 3400\ \text{Hz}\left(\frac{330\ \text{m/s} + 39\ \text{m/s}}{330\ \text{m/s} - 18\ \text{m/s}}\right) = 4021.15\ \text{Hz}.$$

Rounded to two significant figures, $f_o = \boxed{4000\ \text{Hz.}}$

$\boxed{16.73}$

The Doppler effect formula is $f_o = f_s\left(\frac{v+v_o}{v+v_s}\right)$ #1.
Assuming you (the observer) are stationary, $v_o = 0$. And we are told that $f_o = 0.86 f_s$. Substituting this information into eq #1,

$$0.86 \cancel{f_s} = \cancel{f_s}\left(\frac{v}{v+v_s}\right) \longrightarrow 0.86 = \frac{v}{v+v_s} \quad \#2.$$

Eq #2 can be rearranged to solve for v_s:

$$v_s = \frac{v}{0.86} - v = v\left[\frac{1}{0.86} - 1\right]$$

with $v = 343\ m/s$,

$$v_s = 343\ m/s\left[\frac{1}{0.86} - 1\right] = 55.8372\ m/s.$$

Rounded to two significant figures, $v_s = \boxed{56\ m/s.}$

$\boxed{16.85}$

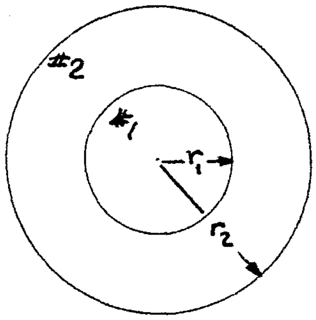
$m/L = 7.8 \times 10^{-4}\ kg/m$
$f = 440\ Hz.$
$\lambda = 65\ cm. = 0.65\ m = 0.65\ m/cycle$
$F = ?$

Since $v = \left(\frac{F}{m/\ell}\right)^{1/2} \longrightarrow F = v^2(m/\ell)$ #1

And, since $v = \lambda f = (0.65\ m/cycle)(440\ cycles/s) = 286\ m/s$, eq #1 yields

$$F = (286\ m/s)^2(7.8 \times 10^{-4}\ kg/m) = \boxed{64\ N}$$

16.93



Intensity I varies with power P and area A according to the equation

$$I = P/A \quad \#1.$$

Assuming the acoustic power doesn't change (i.e. $P_2 = P_1$) as the travels from region #1 to region #2 and the sound is uniformly distributed over a spherical area (i.e. $A = 4\pi r^2$)

$$I_1 = P_1/A_1 = \frac{P_1}{4\pi r_1^2} \quad \#2 \quad \text{and} \quad I_2 = P_2/A_2 = \frac{P_2}{4\pi r_2^2} \quad \#3$$

Intensity level β is related to intensity by the equation

$$\beta = 10 \log(I/I_0) \quad \#4$$

$$\therefore \beta_1 = 10 \log(I_1/I_0) \quad \#5 \quad \text{and} \quad \beta_2 = 10 \log(I_2/I_0) \quad \#6$$

and the change in intensity level $\beta_2 - \beta_1$ is

$$\beta_2 - \beta_1 = 10 \log(I_2/I_0) - 10 \log(I_1/I_0) = 10 \log\left(\frac{I_2/I_0}{I_1/I_0}\right) \overset{*}{=} 10 \log\left(\frac{I_2}{I_1}\right) \quad \#7$$

Substituting eqs #2 and #3 into eq #7,

$$\beta_2 - \beta_1 = 10 \log\left(\frac{P_2/4\pi r_2^2}{P_1/4\pi r_1^2}\right) = 10 \log\left(\frac{r_1^2}{r_2^2}\right) = 10 \log\left(\frac{r_1}{r_2}\right)^2$$

with $r_2 = 2r_1$, $\beta_2 - \beta_1 = 10 \log\left(\frac{1}{2}\right)^2 = 10 \log\left(\frac{1}{4}\right) = \boxed{-6.0206 \text{ dB}}$

* Notice: I used the logarithmic property

$$\log A - \log B = \log(A/B)$$

$\boxed{16.94}$

Intensity is given by the formula $I = P/A$

In this case, the power (which is energy divided by time) is

$$P = \frac{2.0 \times 10^5 \text{ J}}{1 \text{ s.}} = 2.0 \times 10^5 \text{ W}$$

Since the sound travels uniformly in all directions, we can assume that the sound spreads over a spherical surface of radius 85 m. Using the formula for the area of a sphere,

$$A = 4\pi r^2 = 4\pi (85 \text{ m})^2 = 90{,}792 \text{ m}^2$$

therefore $$I = \frac{2.0 \times 10^5 \text{ W}}{90{,}792 \text{ m}^2} = 2.2028 \text{ W/m}^2$$

Now, to determine the corresponding intensity level,

$$\beta = 10 \log\left(I/I_0\right) = 10 \log\left(\frac{2.2028 \text{ W/m}^2}{1 \times 10^{-12} \text{ W/m}^2}\right) = 10 \log\left(2.2028 \times 10^{12}\right) = 123.42982 \text{ dB}$$

Rounding our answer to two significant digits,

$$\beta = \boxed{120 \text{ dB}}$$