Part V

Part A

1. a (in a longitudinal wave, the material oscillates along the same direction that the wave moves; see section 19.1)
2. c (at a particular location, the phase difference between two waves are constantly changing, leading to constructive then destructive then constructive and so on; see section 21.3)
3. a (compare Figure 22.6[1] with Figure 22.7[1])
4. a (assuming the speed of the wave is the same, the longer wavelength corresponds to a lower frequency via $v = \lambda f$)
5. b (since the frequencies are different, the phase difference between the two are constantly changing; see section 21.3)

Part B

1. According to equation (20.11) on page 392, the observed frequency is given as follows:

   $$f_{\text{obs}} = f_{\text{emitted}} \frac{v \pm v_{\text{obs}}}{v \pm v_{\text{source}}}$$

   where v_{obs} is positive if the observer is moving tward the source and v_{source} is positive if the source is moving away from the observer.

   In this case, the first train is the source and the second train is the observer. The emitted frequency f_{source} is 348 Hz. In the equation, v_{source} is the speed of the source. This will be positive if the source is moving away from the observer (leading to lower frequencies since the denominator gets larger) or negative if the source is moving toward the observer (leading to higher frequencies since the denominator gets smaller). In this case, the source is moving toward the observer and so the speed is negative.

   The speed of the observer, v_{obs} is 30 m/s. This will be positive if the observer is moving toward the source (leading to higher frequencies since the numerator gets larger) or negative if the observer is moving away from the source (leading to higher frequencies). In this case, the observer is moving away from the source and so the speed is negative.

Plugging in, we get:

$$f_{\text{obs}} = (348\ \text{Hz})\frac{(343\ \text{m/s}) - 30\ \text{m/s}}{(343\ \text{m/s}) - 20\ \text{m/s}}$$

Solve to get 337 Hz.

2. (a) For a pipe open on one end, the standing waves look like those in Figure 22.6. For the first harmonic, only one-quarter of the wavelength is present in the pipe. Since the pipe is 50 cm long, that means the wavelength is 200 cm.

   (b) Since the wavelength and frequency are related by $v = \lambda f$, we need the speed of the sound wave in air (see Table 19.1). Plugging in 200 cm for λ and 343 m/s for v, we get a frequency of 171.5 Hz (notice that you need to convert the wavelength to meters to cancel the units in the speed).