Solutions

Each answer shows the steps, then the **result**.

2.1

- where waves overlap, the total displacement is the sum of the individual displacements

2.2

- they must be exactly out of phase (crest meets trough)

2.3

- a point on a standing wave that stays at rest (zero displacement)

3.1 B

- constructively.

3.2 B

- node.

3.3

(a)

- a larger wave (constructive interference)

(b)

- they cancel (destructive interference)

(c)

- the principle of superposition

3.4

(a)

- the beat frequency is the difference of the two frequencies: $f_{\text{beat}} = |f - 440\ \text{Hz}|$, so $|f - 440\ \text{Hz}| = 3\ \text{Hz}$
- $f =$ **437** Hz or **443** Hz

(b)

- if f were 443 Hz, lowering it would bring it closer to 440 Hz and the beats would slow; the beats speed up, so f moves away from 440 Hz
- $f =$ **437** Hz

3.5

(a)

- three loops fit the string; each loop is half a wavelength, so $L = 3\left(\frac{\lambda}{2}\right)$ and $\lambda = \frac{2L}{3}$:

$$\lambda = \frac{2L}{3} = \frac{2(1.20\ \text{m})}{3}$$

- $\lambda =$ **0.80** m

(b)

- wave speed from the wave equation, $v = f\lambda$:

$$v = f\lambda = (150\ \text{Hz})(0.80\ \text{m})$$

- $v =$ **120** m/s

(c)

- the fundamental has one loop, $\lambda_1 = 2L = 2.40$ m, with the same wave speed:

$$f_1 = \frac{v}{\lambda_1} = \frac{120\ \text{m/s}}{2.40\ \text{m}}$$

- $f_1 =$ **50** Hz (or 150 Hz $\div$ 3)