21.75. **Model:** The superposition of two slightly different frequencies creates beats.
Solve: **(a)** The wavelength of the sound initially created by the flutist is

$$\lambda = \frac{342 \text{ m/s}}{440 \text{ Hz}} = 0.77727 \text{ m}$$

When the speed of sound inside her flute has increased due to the warming up of the air, the new frequency of the A note is

$$f' = \frac{346 \text{ m/s}}{0.77727 \text{ m}} = 445 \text{ Hz}$$

Thus the flutist will hear beats at the following frequency:

$$f' - f = 445 \text{ Hz} - 440 \text{ Hz} = 5 \text{ beats/s}$$

Note that the wavelength of the A note is determined by the length of the flute rather than the temperature of air or the increased sound speed.
(b) The initial length of the flute is $L = \frac{1}{2}\lambda = \frac{1}{2}(0.77727 \text{ m}) = 0.3886 \text{ m}$. The new length to eliminate beats needs to be

$$L' = \frac{\lambda'}{2} = \frac{1}{2}\left(\frac{v'}{f}\right) = \frac{1}{2}\left(\frac{346 \text{ m/s}}{440 \text{ Hz}}\right) = 0.3932 \text{ m}$$

Thus, she will have to extend the "tuning joint" of her flute by

$$0.3932 \text{ m} - 0.3886 \text{ m} = 0.0046 \text{ m} = 4.6 \text{ mm}$$