

22. (a) The wave speed is

$$v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{k\Delta\ell}{m/(\ell + \Delta\ell)}} = \sqrt{\frac{k\Delta\ell(\ell + \Delta\ell)}{m}}.$$

(b) The time required is

$$t = \frac{2\pi(\ell + \Delta\ell)}{v} = \frac{2\pi(\ell + \Delta\ell)}{\sqrt{k\Delta\ell(\ell + \Delta\ell)/m}} = 2\pi\sqrt{\frac{m}{k}}\sqrt{1 + \frac{\ell}{\Delta\ell}}.$$

Thus if  $\ell/\Delta\ell \gg 1$ , then  $t \propto \sqrt{\ell/\Delta\ell} \propto 1/\sqrt{\Delta\ell}$ ; and if  $\ell/\Delta\ell \ll 1$ , then  $t \simeq 2\pi\sqrt{m/k} = \text{const.}$