PHY 1150
Doug Davis

Chapter 16; Waves and Sound

16.2, 12, 14a, 14b, 16, 17, 21, 22, 28, 32, 49, 54

16.2 $v = f\lambda$

$$\lambda = v/f$$

$$\lambda = \frac{340 \text{ m/s}}{50 \text{ (1/s)}} = 6.8 \text{ m}$$

$$\lambda = \frac{340 \text{ m/s}}{20\,000 \text{ (1/s)}} = 0.017 \text{ m} = 1.7 \text{ cm}$$

16.12

$$\text{linear mass density} = \frac{\text{mass}}{\text{length}} = \frac{m}{L} = \frac{5.4 \text{ kg}}{9.0 \text{ m}} = 0.6 \ \frac{\text{kg}}{\text{m}}$$

$$v = \frac{2 \times 9.0 \text{ m}}{0.6 \text{ s}} = 30 \ \frac{\text{m}}{\text{s}}$$

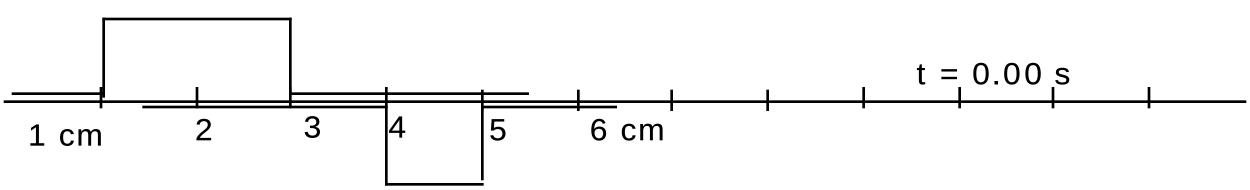
$$v = \sqrt{\frac{T}{m/L}}$$

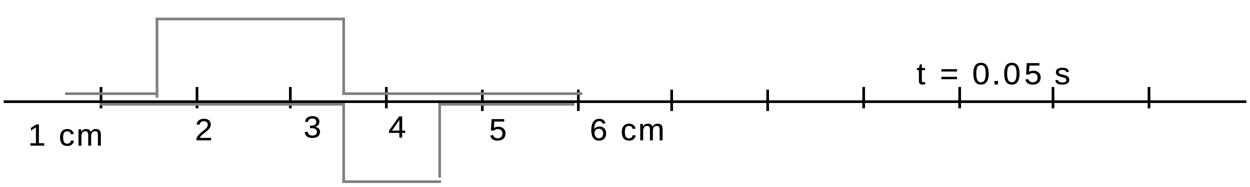
$$v^2 = \frac{T}{m/L}$$

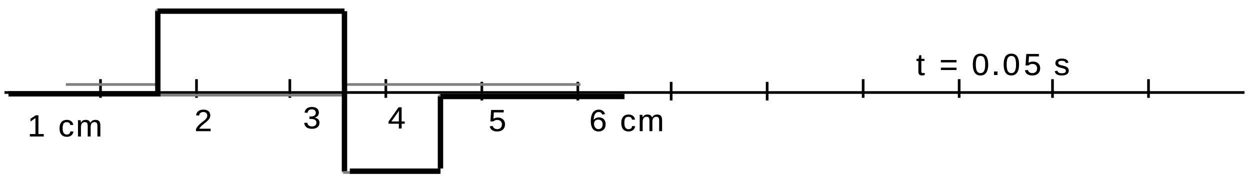
$$T = v^2 (m/L) = (30 \text{ m/s})^2 (0.6 \text{ kg/m})$$

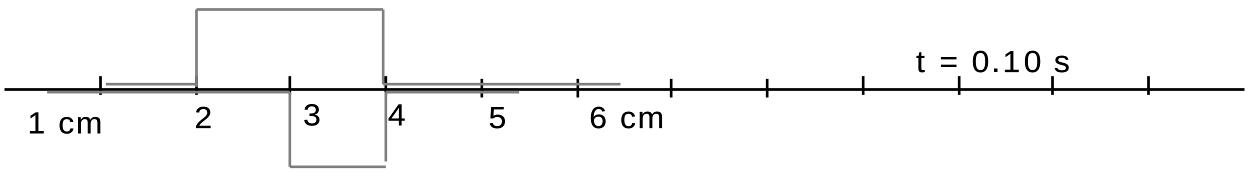
$$T = 540 \text{ N}$$

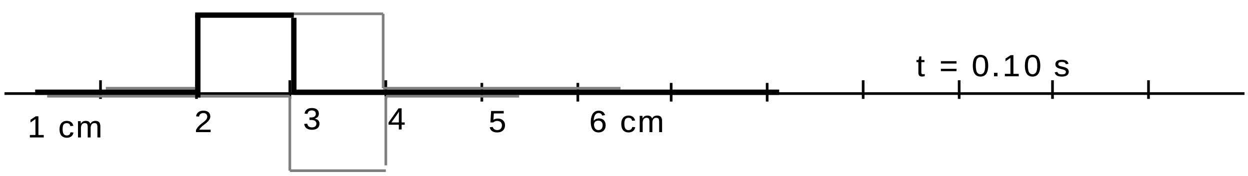
16.14a

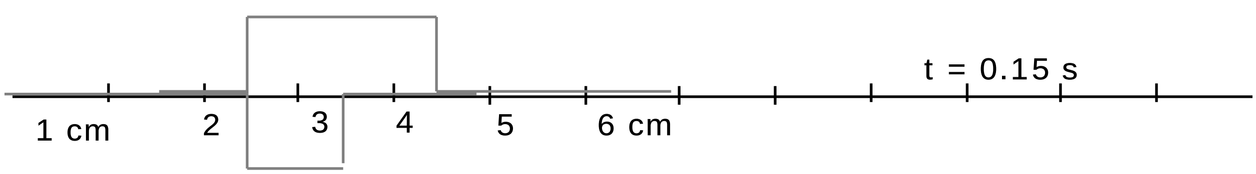


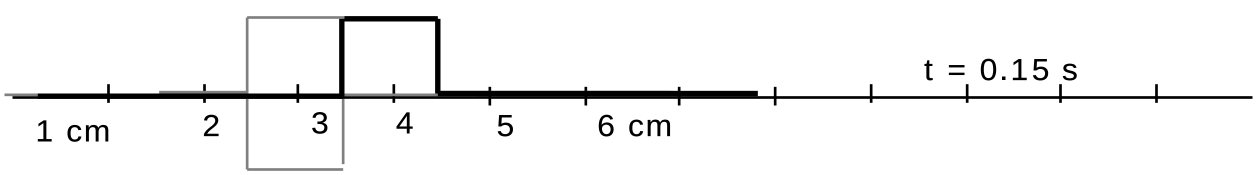


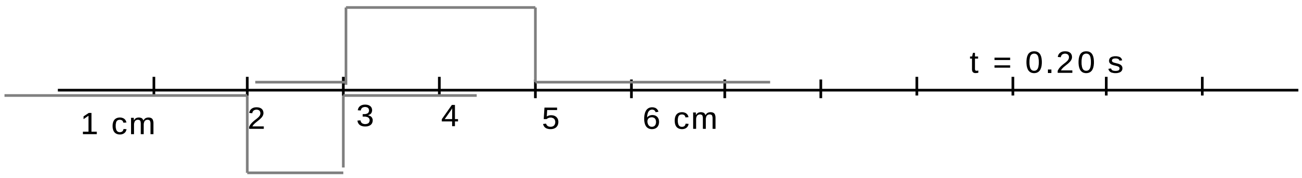

t = 0.05 s
1 cm
2
3
4
5
6 cm

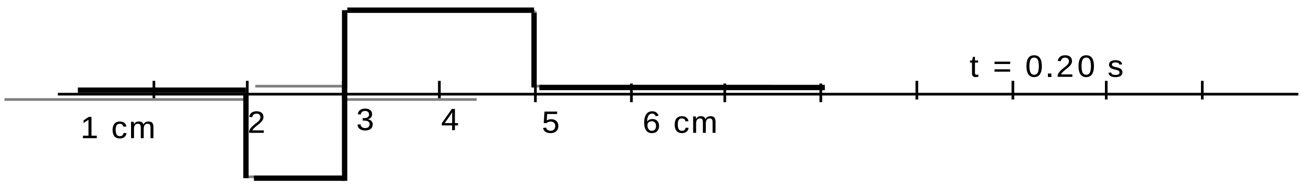

t = 0.10 s
1 cm
2
3
4
5
6 cm

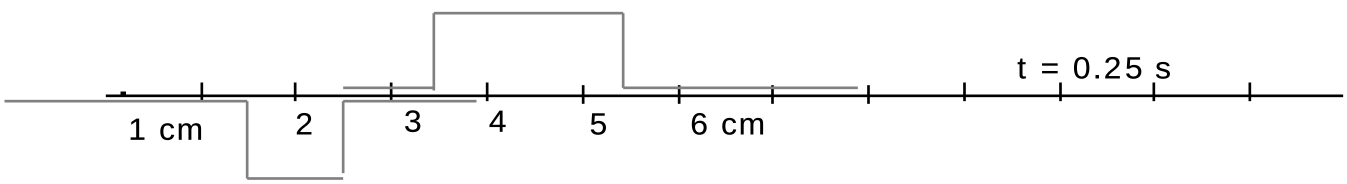

t = 0.10 s
1 cm
2
3
4
5
6 cm

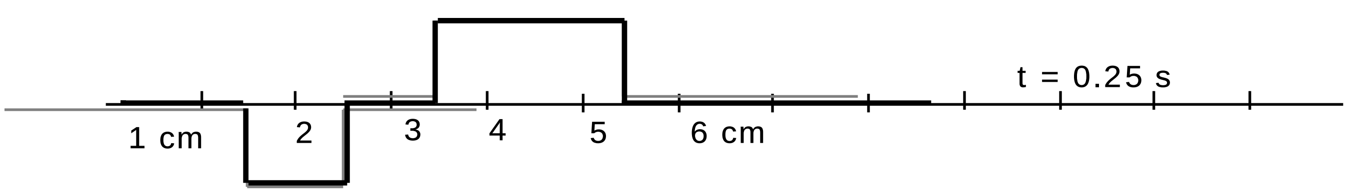

t = 0.15 s
1 cm
2
3
4
5
6 cm


t = 0.15 s
1 cm
2
3
4
5
6 cm

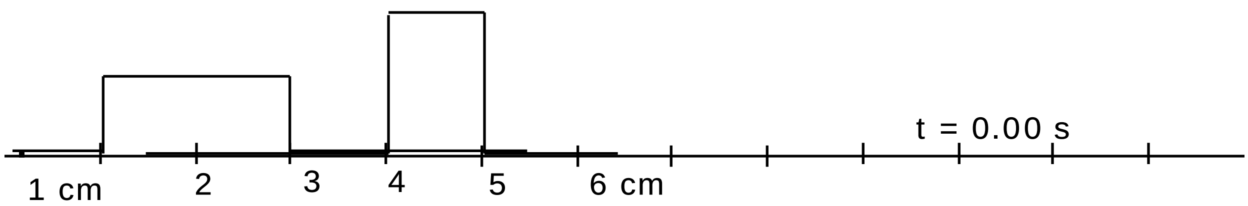

t = 0.20 s
1 cm
2
3
4
5
6 cm

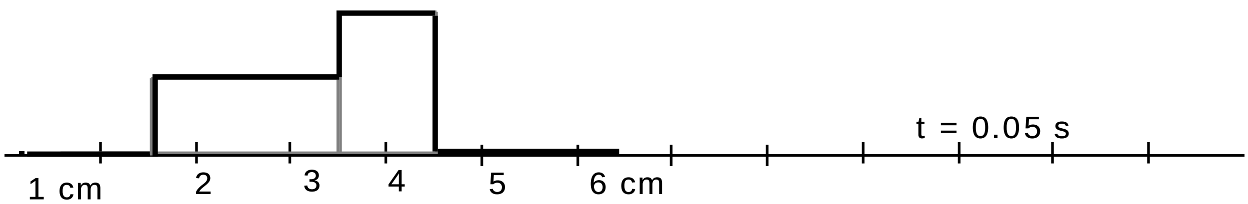

t = 0.20 s
1 cm
2
3
4
5
6 cm

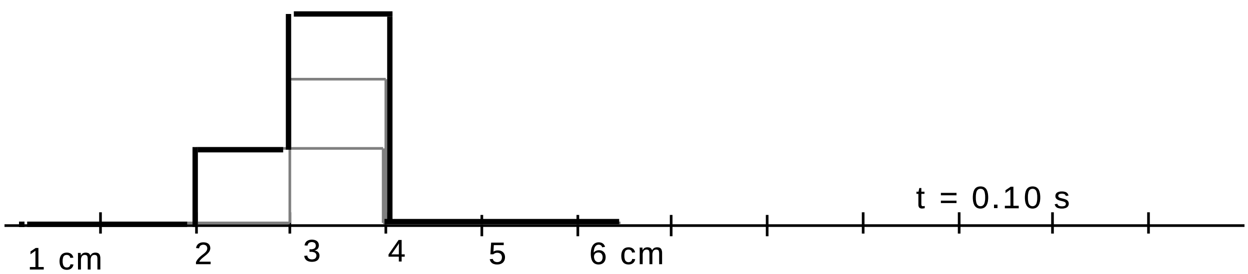

t = 0.25 s
1 cm
2
3
4
5
6 cm

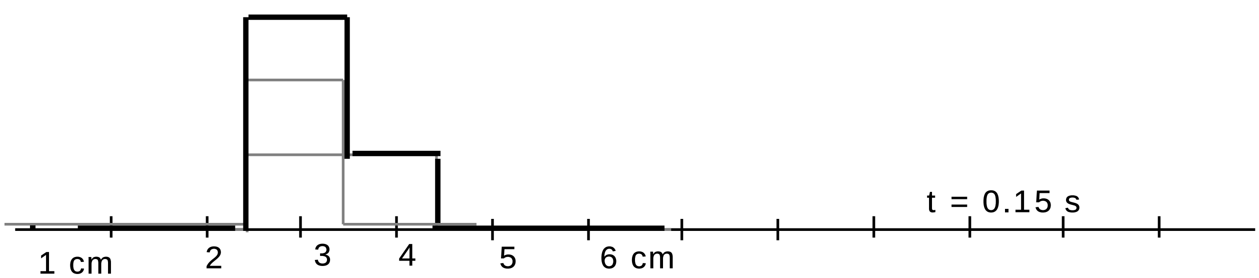

t = 0.25 s
1 cm
2
3
4
5
6 cm

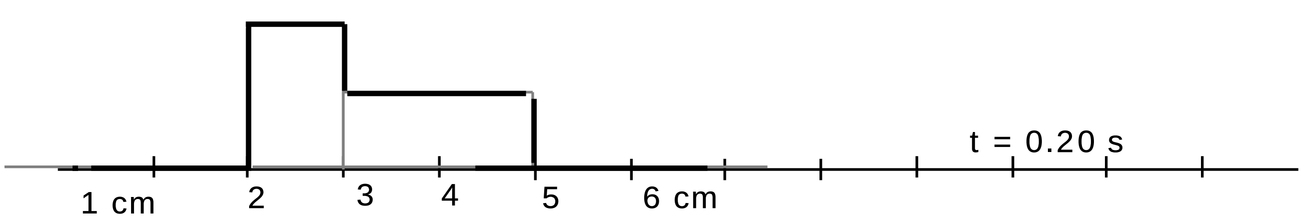
16.14 b

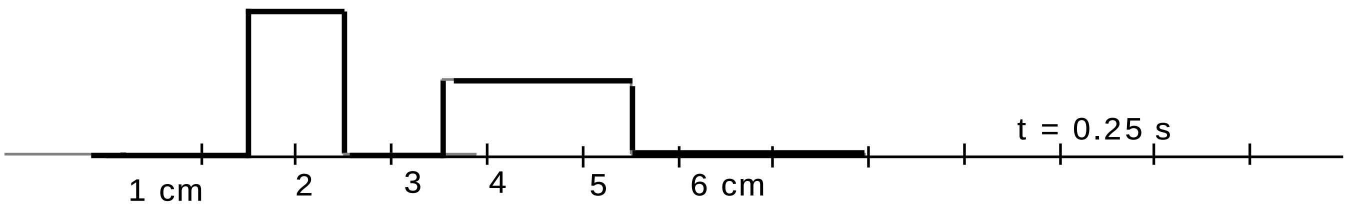

t = 0.00 s
1 cm
2
3
4
5
6 cm


t = 0.05 s
1 cm
2
3
4
5
6 cm


t = 0.10 s
1 cm
2
3
4
5
6 cm


t = 0.15 s
1 cm
2
3
4
5
6 cm


t = 0.20 s
1 cm
2
3
4
5
6 cm



16.16 $f_1 = 440$ Hz

$f_n = n\, f_1$

$f_2 = 880$ Hz

$f_3 = 1\,760$ Hz

$f_4 = 3\,520$ Hz

$f_5 = 7\,040$ Hz

$f_6 = 14\,080$ Hz

$f_7 = 28\,160$ Hz **will be** **ultrasonic**, **and cannot be heard**

16.17 The velocity of the wave on the *string* is given by

$v = f\lambda$

$\lambda/2 = 0.70$ m

$\lambda = 1.4$ m

$v = (440 \text{ Hz})\,(1.4 \text{ m})$

$v = 616$ m/s

$$\lambda = \frac{v}{f} = \frac{616 \text{ m/s}}{524 \text{ (1/s)}} = 1.176 \text{ m}$$

$\lambda/2 = 0.588$ m

That is, your finger should be placed so the string that vibrates is 0.588 m (or 0.59 m) long.

16.21 $\lambda/2 = 2.8 \text{ m}/5 = 0.56$ m

$\lambda = 1.12$ m

$f = 60 \text{ Hz} = 60 \text{ (1/s)}$

$v = f\lambda = (60/\text{s})\,(1.12 \text{ m}) = 67.2$ m/s

$$v = \sqrt{\frac{T}{m/L}}$$

$$v^2 = \frac{T}{m/L}$$

$$T = v^2 (m/L)$$

$$\frac{m}{L} = \frac{0.045 \text{ kg}}{2.4 \text{ m}} = 0.1875 \frac{\text{kg}}{\text{m}}$$

$$T = v^2 (m/L) = (67.2 \text{ m/s})^2 (0.01875 \text{ kg/m}) = 84.67 \text{ N}$$

$$T = m g$$

$$m = \frac{T}{g} = \frac{84.67 \text{ N}}{9.8 \text{ m/s}^2}$$

$$m = 8.64 \text{ kg}$$

16.22 $\frac{\lambda_1}{4} = 1.0 \text{ m}$

$$\lambda_1 = 4.0 \text{ m}$$

$$v = f \lambda$$

$$f = \frac{v}{\lambda}$$

$$f_1 = \frac{v}{\lambda_1} = \frac{340 \text{ m/s}}{4.0 \text{ m}} = 85 \text{ Hz}$$

The next overtone is such an open pipe—exactly like the resonance tubes we used in the lab—has (3/4) of a wavelength.

$$(3/4)\lambda_2 = 1.0 \text{ m}$$

$$\lambda_2 = 1.33 \text{ m}$$

$$f_2 = \frac{v}{\lambda_2} = \frac{340 \text{ m/s}}{1.33 \text{ m}} = 256 \text{ Hz}$$

16.28 This one should be (very) familar!

$$(1/2)\lambda = 0.600 \text{ m} - 0.360 \text{ m} = 0.360 \text{ m} - 0.120 \text{ m} = 0.240 \text{ m}$$

$$\lambda = 0.480 \text{ m}$$

$$v = f \lambda$$

$$f = \frac{v}{\lambda} = \frac{345 \text{ m/s}}{0.480 \text{ m}} = 719 \text{ Hz}$$

16.32 $v = [331 + (0.60)(42)] \text{ m/s}$

$$v = [331 + 25] \text{ m/s}$$

$$v = 356 \text{ m/s}$$

16.49 $f' = f\left(\frac{v + v_{obs}}{v + v_s}\right)$

$$f' = 500\text{ Hz}\left(\frac{340\text{ m/s}}{(340 - 25)\text{ m/s}}\right) = 500\text{ Hz}\left(\frac{340}{315}\right)$$

$f' = (500\text{ Hz})(1.079) = 540\text{ Hz}$

$$f' = 500\text{ Hz}\left(\frac{340}{340 + 25}\right) = 500\text{ Hz}\left(\frac{340}{365}\right)$$

$f' = (500\text{ Hz})(0.932) = 466\text{ Hz}$

$$f' = 500\text{ Hz}\left(\frac{340 + 25}{340}\right) = 500\text{ Hz}\left(\frac{365}{340}\right)$$

$f' = (500\text{ Hz})(1.074) = 537\text{ Hz}$

$$f' = 500\text{ Hz}\left(\frac{340 - 25}{340}\right) = 500\text{ Hz}\left(\frac{315}{340}\right)$$

$f' = (500\text{ Hz})(0.926) = 463\text{ Hz}$

16.54 $f' = f\left(\frac{v + v_{obs}}{v + v_s}\right)$

$f = 550\text{ Hz}$
$v = 340\text{ m/s}$
$v_{obs} = 0$
$v_s = ?$ (we are looking for the velocity of the source).

A beat frequency of 2 Hz means the frequency heard from the moving train's horn must be different from 550 Hz by 2. Therefore, for the approaching train, the frequency heard must be 552 Hz, and for the train going away, the frequency heard must be 548 Hz.

$$f' = 552\text{ Hz} = 550\text{ Hz}\left(\frac{340}{340 - v_s}\right)$$

$$\left(\frac{340}{340 - v_s}\right) = \frac{552}{550} = 1.0036$$

$340 = (1.0036)(340 - v_s) = 341.236 - 1.0036\, v_s$

$1.0036\, v_s = 1.236$

$$v_s = \frac{1.236}{1.0036} = 1.23\text{ m/s}$$

$$f' = 548\text{ Hz} = 550\text{ Hz}\left(\frac{340}{340 + v_s}\right)$$

$$\left(\frac{340}{340 + v_s}\right) = \frac{548}{550} = 0.9964$$

$$340 = (0.9964)(340 + v_s) = 338.764 + 0.9964\, v_s$$

$$0.9964\, v_s = 1.236$$

$$v_s = \frac{1.236}{0.9964} = 1.24 \text{ m/s}$$

Remember, however, the "beat frequency of 2 Hz" is stated to only <u>one</u> significant figure. We are unjustified in keeping <u>three</u> significant figures in our answers.