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Chapter **17** (Benson)

Sound speed $v_{air} = 340\,\text{m/s}$ & density $\rho_{air} = 1.29\,\text{kg/m}^3$.

E01 $\lambda = v/f = 3.4\,\text{mm}$.

E05 (**a**) $v = \sqrt{B/\rho} = 1.43\,\text{km/s}$; (**b**) $\lambda = v/f = 1.43\,\text{m}$.

E13 $\lambda = v/f = 77.3\,\text{cm}$. $L_1 = \lambda/4 = 19.3\,\text{cm}$; $L_2 = 3\lambda/4 = 58.0\,\text{cm}$.

E14 $f = v/2L$, $2f = v\,(1/L)$. The slope of the curve $2f$ vs $1/L$ is the sound speed. $v = 350\,\text{m/s}$ by least square fitting.

E19 (**a**) $f = v/2L = 283\,\text{Hz}$; (**b**) $L = v/2f = 51.5\,\text{cm}$.

E22 (**a**) $f = 1200\,\text{Hz}$, $v_c = 108\,\text{km/h} = 30\,\text{m/s}$; $f' = 1200{\times}340/(340-30) = 1320\,\text{Hz}$; (**b**) $f' = 1200{\times}340/(340+30) = 1100\,\text{Hz}$.

E25 (**a**) $f = 200\,\text{Hz}$, $v_s = 40\,\text{m/s}$; $f' = 200{\times}340/(340-40) = 227\,\text{Hz}$; $\lambda' = v/f' = 1.50\,\text{m}$; (**b**) $v_l = 40\,\text{m/s}$, $f' = 200{\times}380/340 = 224\,\text{Hz}$, $\lambda' = v'/f' = 380/224 = 1.70\,\text{m}$; (**c**) $v_s = 20\,\text{m/s}$; $v_l = 20\,\text{m/s}$, $f' = 200{\times}360/320 = 225\,\text{Hz}$; $\lambda' = v'/f' = 360/225 = 1.60\,\text{m}$.

E27 (**a**) $f = 400\,\text{Hz}$, $v_c = 40\,\text{m/s}$, $v_t = 15\,\text{m/s}$, $f_1' = 400{\times}(340-15)/(340-40) = 433.3\,\text{Hz}$, $f_2' = 400{\times}(340+15)/(340+40) = 373.7\,\text{Hz}$. $\Delta f' = 59.6\,\text{Hz}$; (**b**) $f_1' = 400{\times}(340+15)/(340-40) = 473.3\,\text{Hz}$, $f_2' = 400{\times}(340-15)/(340+40) = 342.1\,\text{Hz}$. $\Delta f' = 131\,\text{Hz}$.

E34 $100 = 10\log(I/I_0) = 10\log I + 120$, thus $I = 10^{-2}\,\text{W/m}^2$;
$P = IA = (10^{-2})(4\pi 40^2) = 201\,\text{W}$.

E47 $F \propto f^2$, and F must be decreased, so $F_2 = (220/222)F_1 = 589\,\text{Hz}$.

E49 (**a**) $1300/929 = 1.40$, $(n+1)/n = 1.4$ gives $n = 2.5$, so pipe is not open; but $(n+2)/n = 1.4$ gives $n = 5$, so pipe is closed. (**b**) $5v/4L = 929$, so $v = 334\,\text{m/s}$.

E50 At wall: $f_1 = f_0 v/(v - v_s) = 658\,\text{Hz}$. Back at car: $f_2 = f_1(v + v_s)/v = 716\,\text{Hz}$.

E56 $f = 800\,\text{Hz}$, $v_c = 40\,\text{m/s}$, $v_t = 25\,\text{m/s}$. $f_1' = 800{\times}(340-25)/(340-40) = 840\,\text{Hz}$, $f_2' = 800{\times}(340+25)/(340+40) = 768\,\text{Hz}$. $\Delta f' = -71.6\,\text{Hz}$.

P03 (**a**) $v \approx 20\sqrt{T}$, $dv/dT = 20/2\sqrt{T}$, thus $dv/v = dT/2T$; (**b**) $f \propto v$, $df/f = dv/v = dT/2T$, thus $df = 10(400)/285 = 14\,\text{Hz}$, thus $f = 414\,\text{Hz}$; (**c**) $df/f = 10/285 = 3.51\%$.

P04 (**a**) Try open: $850/607 = (n+1)/n$, thus $n = 2.5$, so cannot be open. Try closed: $850/607 = (n+2)/n$, thus $n = 5$, i.e. closed. (**b**) $f_1 = f_5/5 = 607/5 = 121.4\,\text{Hz}$.

P05 $H = gt_1^2/2$, $H = 340t_2$, $t_1 + t_2 = 2.2\,\text{s}$, thus $(H/4.9)^{1/2} + H/340 - 2.2 = 0$. Solve for $H^{1/2}$, then find $H = 22.3\,\text{m}$. (Teacher: Jyh-Shinn Yang, 90.03.21)

P09 (**a**) $f = 404\,\text{Hz}$ or $396\,\text{Hz}$; (**b**) $L = 52\,\text{cm}$, $\mu = 2\,\text{g/m}$, & $f = \sqrt{F/\mu}/2L = 400\,\text{Hz}$, so $F = (2Lf)^2\mu = 346\,\text{N}$; (**c**) Now know $f = 404\,\text{Hz}$, $f = v/2L$, thus $L = 42.1\,\text{cm}$.