Chapter **16** (Benson)

E01 $\lambda = c/f$: (**a**) 188 m to 546 m; (**b**) 2.78 m to 3.41 m .

E05 v_p, $v_s = 8$, 5 km/s & $\Delta t = 1.8$ min. $\Delta t = \Delta x/v_s - \Delta x/v_p \Rightarrow \Delta x = 1440$ km .

E06 $m = 25$ g, $l = 3$ m & $v = 40$ m/s $\Rightarrow F = v^2\mu = 13.3$ N .

E15 $y(x,t) = A\sin(kx - \omega t)$: (**a**) $\partial y/\partial x = kA\cos(kx - \omega t)$; (**b**) $(\partial y/\partial t)_m = v\,(\partial y/\partial x)_m$.

E17 $y(x,t) = 2.4\cos[(\pi/20)(0.5x - 40t)]$, x, y in cm & t in sec. $\Rightarrow k = 0.025\pi$ cm^{-1}, $\omega = 2\pi$ s^{-1} & $A = 2.4$cm: (**a**) $(\partial y/\partial t)_m = \omega A = 4.8\pi = 15.1$(cm/s); (**b**) $x = 1.5$cm & $t = 0.25$s, $(\partial y/\partial t) = 4.8\pi\sin(0.375\pi - 0.5\pi) = 4.8\pi\sin(-1.453) = -15.0$(cm/s); (**c**) $a_m = \omega^2 A = 94.7$ cm/s^2; (**d**) $a = -\omega^2 A\cos(-1.453) = -11.1$ cm/s^2 .

E18 $y(x,t) = 0.03\cos(2.4x - 12t + 0.1)$, x, y in cm & t in sec. $\Rightarrow k = 2.4$ cm^{-1}, $\omega = 12$ s^{-1} & $A = 0.03$ cm: (**a**) $f = \omega/2\pi = 1.91$ Hz; (**b**) $v = \omega/k = 5$ cm/s; (**c**) $A = 0.03$ cm; (**d**) $x = 15$ cm & $t = 0.2$ s, $(\partial y/\partial t) = 0.36\sin(36 - 2.4 + 0.1) = 0.36\sin(33.7) = 0.272$ (cm/s); (**e**) $a_m = \omega^2 A = 4.32$ cm/s^2 .

E22 $y(x,t) = 0.04\sin(x/5 - 2t)$, x, y in m & t in sec. $\Rightarrow k = 0.2$ m^{-1}, $\omega = 2$ s^{-1} & $A = 0.04$ m: (**a**) $\lambda = 2\pi/k = 31.4$ m; (**b**) $\tau = 2\pi/\omega = 3.14$ s; (**c**) $v = \omega/k = 10$ m/s .

E29 (**a**) $\lambda = 2L/n$: $\lambda_{n-1} = 36$ cm & $\lambda_n = 32$ cm $\Rightarrow \lambda_n : \lambda_{n-1} = 8 : 9 \Rightarrow n = 8$, $L = n\lambda_n/2 = (8)(36)/2 = 144$ cm; (**b**) $T = 10$ N, $\mu = 4$ g/m, $f_1 = (1/2L)\sqrt{F/\mu} = 17.4$ Hz .

E30 $f_n = 480$ Hz, $f_{n+1} = 600$ Hz, $T = 12$ N & $\mu = 2.6$ g/m.
(**a**) $f_1 = f_n - f_{n-1} = 120$ Hz; (**b**) $L = \sqrt{F/\mu}/(2f_1) = 0.283$ m .

E33 $L_1 = L_2$ & $T_1 = T_2$. $\mu L = \pi r^2 L\rho \Rightarrow \mu_1/\mu_2 = r_1^2\rho_1/(r_2^2\rho_2) = 2.0$. $f_2/f_1 = \sqrt{\mu_1/\mu_2} = \sqrt{2}$.

E37 $P = \mu(\omega A)^2 v/2 = 15$ W .

E49 $y(x,t) = 2.4\times10^{-3}\sin(36x - 270t)$ m, x in m & t in sec. $F = 0.18$ N. (**a**) $\mu = Fk^2/\omega^2 = 3.2$ (g/m); (**b**) $v_m = \omega A = 0.648$ (m/s) .

E53 $f \propto 1/\sqrt{\mu}$, $f_2 = f_1\sqrt{\mu_1/\mu_2} = 180/\sqrt{2} = 127$ (Hz) .

E54 (**a**) $v = 2fL = 132$ m/s; (**b**) $\mu = 0.003$ g/m, $F = \mu v^2 = 52.3$ (N) .

P02 (**a**) $f \propto \sqrt{F}$, thus $\Delta f/\Delta F \propto 1/(2\sqrt{F})$, $\Delta f/f = \Delta F/2F$; (**b**) $\Delta f = 0.5f(\Delta F/F) = 0.5(400)(-0.03) = -6$ (Hz), so $f' = 394$ Hz; (**c**) $\Delta f/f = 2/260$, thus $\Delta F/F = 2\Delta f/f = 1.54\%$. (Teacher: Jyh-Shinn Yang, 90.03.20)

P04 $L_G = 64$ cm, $f \propto 1/L$, $L_A = L_G(196)/220$: $L_A = 57$ cm, $\Delta L_G = 7$ cm; $L_B = L_G(196)/247$, $L_B = 50.8$ cm, $\Delta L_B = 13.2$ cm; $L_C = L_G(196)/262$, $L_C = 47.9$ cm, $\Delta L_C = 16.1$ cm; $L_D = L_G(196)/294$, $L_D = 42.7$ cm, $\Delta L_D = 21.3$ cm .

P05 (**a**) $P = F_y(\partial y/\partial t) = F(-\partial y/\partial x)(\partial y/\partial t)$; (**b**) $P_{av} = \mu(\omega A)^2 v/2$.

P06 $F(y) = \mu g y$, $v(y) = dy/dt = \sqrt{gy}$. $\Delta t = \int dt = \int_0^L dy/\sqrt{gy} = 2\sqrt{L/g}$.

P08 $x = 0$ is a node, $x = L$ is an antinode. Thus $L = \lambda/4, 3\lambda/4, 5\lambda/4 \cdots$, i.e. $f = v/\lambda = v/(4L), 3v/(4L), 5v/(4L) \cdots$. Thus $f = (2n-1)\sqrt{F/\mu}/(4L)$.

P09 $v = \sqrt{F/\mu} = \sqrt{F/A\rho}$ but $F/A = Y\Delta L/L$, thus $v = \sqrt{Y\Delta L/\rho L}$.

(Teacher: Jyh-Shinn Yang, 90.03.20)