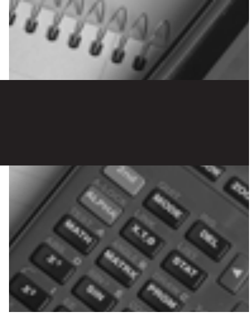

Vibrations and Waves

Vibrations and Waves, Practice A

Givens | *Solutions*

1. $x = -36$ cm

$m = 0.55$ kg

$g = 9.81$ m/s^2

a. $F_g + F_{elastic} = 0$

$F_g = -mg$

$F_{elastic} = -kx$

$-mg - kx = 0$

$$k = \frac{-mg}{x} = \frac{-(0.55\text{ kg})(9.81\text{ m/s}^2)}{-0.36\text{ m}} = \boxed{15\text{ N/m}}$$

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2. $F_g = -45$ N

$x = -0.14$ m

$F_g + F_{elastic} = 0$

$F_g + (-kx) = 0$

$$k = \frac{F_g}{x} = \frac{-45\text{ N}}{-0.14\text{ m}} = \boxed{3.2 \times 10^2\text{ N/m}}$$

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3. $F_1 = 32$ N

$x_1 = -1.2$ cm

$$k = \frac{-F_1}{x_1} = \frac{-32\text{ N}}{-0.012\text{ m}} = \boxed{2.7 \times 10^3\text{ N/m}}$$

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4. $x_2 = -3.0$ cm

$F_2 = -kx_2$

$$F_2 = -(2.7 \times 10^3\text{ N/m})(-0.030\text{ m}) = \boxed{81\text{ N}}$$

Vibrations and Waves, Section 1 Review

2. $x = -4.0$ cm

$k = 13$ N/m

$F = -kx = -(13\text{ N/m})(-0.040\text{ m})$

$$F = \boxed{0.52\text{ N}}$$

Vibrations and Waves, Practice B

1. $T = 24$ s

$a_g = g = 9.81$ m/s^2

$$T = 2\pi\sqrt{\frac{L}{a_g}}$$

$$L = a_g\left(\frac{T}{2\pi}\right)^2 = (9.81\text{ m/s}^2)\left(\frac{24\text{ s}}{2\pi}\right)^2 = \boxed{1.4 \times 10^2\text{ m}}$$

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2. $T = 1.0$ s

$a_g = g = 9.81$ m/s^2

$$T = 2\pi\sqrt{\frac{L}{a_g}}$$

$$L = a_g\left(\frac{T}{2\pi}\right)^2 = (9.81\text{ m/s}^2)\left(\frac{1.0\text{ s}}{2\pi}\right)^2 = 0.25\text{ m} = \boxed{25\text{ cm}}$$

Givens | *Solutions*

3. $T = 3.8$ s

$a_g = g = 9.81$ m/s^2

$$T = 2\pi\sqrt{\frac{L}{a_g}}$$

$$L = a_g\left(\frac{T}{2\pi}\right)^2 = (9.81 \text{ m/s}^2)\left(\frac{3.8 \text{ s}}{2\pi}\right)^2 = \boxed{3.6 \text{ m}}$$

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4. $L = 3.500$ m

$a_g = 9.832$ m/s^2

a. $$T_1 = 2\pi\sqrt{\frac{L}{a_g}} = 2\pi\sqrt{\frac{3.500 \text{ m}}{9.832 \text{ m/s}^2}} = \boxed{3.749 \text{ s}}$$

$$f_1 = \frac{1}{T_1} = \frac{1}{3.749 \text{ s}} = \boxed{0.2667 \text{ Hz}}$$

$a_g = 9.803$ m/s^2

b. $$T_2 = 2\pi\sqrt{\frac{L}{a_g}} = 2\pi\sqrt{\frac{3.500 \text{ m}}{9.803 \text{ m/s}^2}} = \boxed{3.754 \text{ s}}$$

$$f_2 = \frac{1}{T_2} = \frac{1}{3.754 \text{ s}} = \boxed{0.2664 \text{ Hz}}$$

$a_g = 9.782$ m/s^2

c. $$T_3 = 2\pi\sqrt{\frac{L}{a_g}} = 2\pi\sqrt{\frac{3.500 \text{ m}}{9.782 \text{ m/s}^2}} = \boxed{3.758 \text{ s}}$$

$$f_3 = \frac{1}{T_3} = \frac{1}{3.758 \text{ s}} = \boxed{0.2661 \text{ Hz}}$$

Vibrations and Waves, Practice C

1. $T = 0.24$ s

$m = 0.30$ kg

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$k = \frac{4\pi^2 m}{T^2} = \frac{4\pi^2 (0.30 \text{ kg})}{(0.24 \text{ s})} = \boxed{2.1 \times 10^2 \text{ N/m}}$$

2. $m = 25 \text{ g} = 0.025$ kg

$f = \dfrac{20 \text{ vibrations}}{4.0 \text{ s}} = 5.0$ Hz

$$T = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k}}$$

$$k = 4\pi^2 m f^2 = 4\pi^2(0.025 \text{ kg})(5.0 \text{ Hz})^2 = \boxed{25 \text{ N/m}}$$

3. $F = 125$ N

$g = 9.81$ m/s^2

$T = 3.56$ s

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{F}{g\,k}}$$

$$k = \frac{4\pi^2 F}{g\,T^2} = \frac{(4\pi^2)(125 \text{ N})}{(9.81 \text{ m/s}^2)(3.56 \text{ s})^2}$$

$$k = \boxed{39.7 \text{ N/m}}$$

4. $m_p = 255$ kg

$m_c = 1275$ kg

$k = 2.00 \times 10^4$ N/m

$$m = \frac{m_p + m_c}{4} = \frac{255 \text{ kg} + 1275 \text{ kg}}{4} = \frac{1.530 \times 10^3 \text{ kg}}{4} = 382.5 \text{ kg}$$

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{382.5 \text{ kg}}{2.00 \times 10^4 \text{ N/m}}} = \boxed{0.869 \text{ s}}$$

Givens	*Solutions*
5. $k = 30.0$ N/m $m_1 = 2.3$ kg	**a.** $T_1 = 2\pi\sqrt{\frac{m_1}{k}} = 2\pi\sqrt{\frac{2.3 \text{ kg}}{30.0 \text{ N/m}}}$ $T_1 = \boxed{1.7 \text{ s}}$ $f_1 = \frac{1}{T_1} = \frac{1}{1.7 \text{ s}} = \boxed{0.59 \text{ Hz}}$
$m_2 = 15$ g	**b.** $T_2 = 2\pi\sqrt{\frac{m_2}{k}} = 2\pi\sqrt{\frac{0.015 \text{ kg}}{30.0 \text{ N/m}}}$ $T_2 = \boxed{0.14 \text{ s}}$ $f_2 = \frac{1}{T_2} = \frac{1}{0.14 \text{ s}} = \boxed{7.1 \text{ Hz}}$
$m_3 = 1.9$ kg	**c.** $T_3 = 2\pi\sqrt{\frac{m_3}{k}} = 2\pi\sqrt{\frac{1.9 \text{ kg}}{30.0 \text{ N/m}}}$ $T_3 = \boxed{1.6 \text{ s}}$ $f_3 = \frac{1}{T_3} = \frac{1}{1.6 \text{ s}} = \boxed{0.62 \text{ Hz}}$

Vibrations and Waves, Section 2 Review

1. $f = 180$ oscillations/min	$f = (180 \text{ oscillations/min})(1 \text{ min}/60 \text{ s})$ $f = \boxed{3.0 \text{ Hz}}$ $T = \frac{1}{f} = \frac{1}{3.0 \text{ Hz}} = \boxed{0.33 \text{ s}}$
2. $L = 2.5$ m $a_g = g = 9.81 \text{ m/s}^2$	**a.** $T = 2\pi\sqrt{\frac{L}{a_g}} = 2\pi\sqrt{\frac{2.5 \text{ m}}{9.81 \text{ m/s}^2}}$ $T = \boxed{3.2 \text{ s}}$ **b.** $f = \frac{1}{T} = \frac{1}{3.2 \text{ s}} = \boxed{0.31 \text{ Hz}}$
3. $m = 0.75$ kg $x = -0.30$ m $g = 9.81 \text{ m/s}^2$	**a.** $-kx - mg = 0$ $k = \frac{-mg}{x} = \frac{-(0.75 \text{ kg})(9.81 \text{ m/s}^2)}{-0.30 \text{ m}}$ $k = \boxed{25 \text{ N/m}}$ **b.** $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.75 \text{ kg}}{25 \text{ N/m}}}$ $T = \boxed{1.1 \text{ s}}$

Vibrations and Waves, Practice D

1. $f_1 = 28$ Hz $f_2 = 4200$ Hz $v = 340$ m/s	$\lambda_1 = \frac{v}{f_1} = \frac{340 \text{ m/s}}{28 \text{ Hz}} = \boxed{12 \text{ m}}$ $\lambda_2 = \frac{v}{f_2} = \frac{340 \text{ m/s}}{4200 \text{ Hz}} = \boxed{0.081 \text{ m}}$

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Givens	*Solutions*
2. $v = 3.00 \times 10^8$ m/s $f_1 = 88.0$ MHz	**a.** $\lambda_1 = \frac{v}{f_1} = \frac{3.00 \times 10^8 \text{ m/s}}{8.80 \times 10^7 \text{ Hz}}$ $\lambda_1 = \boxed{3.41 \text{ m}}$
$f_2 = 6.0 \times 10^8$ MHz	**b.** $\lambda_2 = \frac{v}{f_2} = \frac{3.00 \times 10^8 \text{ m/s}}{6.0 \times 10^{14} \text{ Hz}}$ $\lambda_2 = \boxed{5.0 \times 10^{-7} \text{ m}}$
$f_3 = 3.0 \times 10^{12}$ MHz	**c.** $\lambda_3 = \frac{v}{f_3} = \frac{3.00 \times 10^8 \text{ m/s}}{3.0 \times 10^{18} \text{ Hz}}$ $\lambda_3 = \boxed{1.0 \times 10^{-10} \text{ m}}$
3. $\lambda = 633$ nm $= 6.33 \times 10^{-7}$ m $v = 3.00 \times 10^8$ m/s	$f = \frac{v}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{6.33 \times 10^{-7} \text{ m}}$ $f = \boxed{4.74 \times 10^{14} \text{ Hz}}$
4. $f = 256$ Hz $\lambda_{air} = 1.35$ m $v_{water} = 1500$ m/s	**a.** $v_{air} = \lambda_{air} f = (1.35 \text{ m})(256 \text{ Hz})$ $v_{air} = \boxed{346 \text{ m/s}}$ **b.** $\lambda_{water} = \frac{v_{water}}{f} = \frac{1500 \text{ m/s}}{256 \text{ Hz}}$ $\lambda_{water} = \boxed{5.86 \text{ m}}$

Vibrations and Waves, Section 3 Review

5. $\lambda = 0.57 \text{ cm} = 5.7 \times 10^{-3}$ m $v = 340$ m/s	$f = \frac{v}{\lambda} = \frac{340 \text{ m/s}}{5.7 \times 10^{-3} \text{ m}}$ $f = \boxed{6.0 \times 10^4 \text{ Hz}}$

Vibrations and Waves, Chapter Review

8. $m = 0.40$ kg $x = -3.0$ cm $g = 9.81 \text{ m/s}^2$	$-kx - mg = 0$ $k = \frac{-mg}{x} = \frac{-(0.40 \text{ kg})(9.81 \text{ m/s}^2)}{-0.030 \text{ m}}$ $k = \boxed{130 \text{ N/m}}$
9. $x = -0.40$ m $F = 230$ N	$k = \frac{-F}{x} = \frac{-230 \text{ N}}{-0.40 \text{ m}} = \boxed{580 \text{ N/m}}$
19. $f = 0.16$ Hz $a_g = g = 9.81 \text{ m/s}^2$	$T = \frac{1}{f} = 2\pi\sqrt{\frac{L}{a_g}}$ $L = \frac{a_g}{(2\pi f)^2} = \frac{(9.81 \text{ m/s}^2)}{(4\pi^2)(0.16 \text{ Hz})^2}$ $L = \boxed{9.7 \text{ m}}$

Givens	*Solutions*
20.	**a.** Because a pendulum passes through its equilibrium position twice each cycle, $T = (2)(1.000\ \text{s}) = \boxed{2.000\ \text{s}}$.
$L_1 = 0.9942$ m	**b.** $a_g = \frac{4\pi^2 L_1}{T^2} = \frac{(4\pi^2)(0.9942\ \text{m})}{(2.000\ \text{s})^2}$ $a_g = \boxed{9.812\ \text{m/s}^2}$
$L_2 = 0.9927$ m	**c.** $a_g = \frac{4\pi^2 L_2}{T^2} = \frac{(4\pi^2)(0.9927\ \text{m})}{(2.000\ \text{s})^2}$ $a_g = \boxed{9.798\ \text{m/s}^2}$
21. $k = 1.8 \times 10^2$ N/m $m = 1.5$ kg	**a.** $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{1.5\ \text{kg}}{1.8 \times 10^2\ \text{N/m}}}$ $T = \boxed{0.57\ \text{s}}$ **b.** $f = \frac{1}{T} = \frac{1}{0.57\ \text{s}} = \boxed{1.8\ \text{Hz}}$
34. $f = 25.0$ Hz $\frac{1}{2}\lambda = 10.0$ cm 2(amplitude) = 18 cm	**a.** amplitude $= \frac{18\ \text{cm}}{2} = \boxed{9.0\ \text{cm}}$ **b.** $\lambda = (2)(10.0\ \text{cm}) = \boxed{20.0\ \text{cm}}$ **c.** $T = \frac{1}{f} = \frac{1}{25.0\ \text{Hz}} = \boxed{0.0400\ \text{s}}$ **d.** $v = \lambda f = (0.200\ \text{m})(25.0\ \text{Hz}) = \boxed{5.00\ \text{m/s}}$
35. $v = 3.00 \times 10^8$ m/s $f = 9.00 \times 10^9$ Hz	$\lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ \text{m/s}}{9.00 \times 10^9\ \text{Hz}} = \boxed{0.0333\ \text{m}}$
44. $k = 230$ N/m $x = -6.0$ cm	$F = -kx$ $F = -(230\ \text{N/m})(-0.060\ \text{m})$ $F = \boxed{14\ \text{N}}$
45. $x = -2.0$ cm $k = 85$ N/m	$F = -kx = -(85\ \text{N/m})(-0.020\ \text{m})$ $F = \boxed{1.7\ \text{N}}$
46. $\lambda = 0.15$ m	Because a wave is generated twice each second, $f = \boxed{2.0\ \text{Hz}}$. $T = \frac{1}{f} = \frac{1}{2.0\ \text{Hz}} = \boxed{0.50\ \text{s}}$ $v = \lambda f = (0.15\ \text{m})(2.0\ \text{Hz}) = \boxed{0.30\ \text{m/s}}$

Givens	*Solutions*
47. $v = 343$ m/s $\Delta t = 2.60$ s	$\Delta x = \frac{v\Delta t}{2} = \frac{(343 \text{ m/s})(2.60 \text{ s})}{2} = \boxed{446 \text{ m}}$
48. $f_1 = 196$ Hz $f_2 = 2637$ Hz $v = 340$ m/s	$\lambda_1 = \frac{v}{f_1} = \frac{340 \text{ m/s}}{196 \text{ Hz}} = \boxed{1.73 \text{ m}}$ $\lambda_2 = \frac{v}{f_2} = \frac{340 \text{ m/s}}{2637 \text{ Hz}} = \boxed{0.129 \text{ m}}$
49. $L = 0.850$ m $T = 1.86$ s	$T = 2\pi\sqrt{\frac{L}{a_g}}$ $a_g = \frac{4\pi^2 L}{T^2} = \frac{(4\pi^2)(0.850 \text{ m})}{(1.86 \text{ s})^2} = \boxed{9.70 \text{ m/s}^2}$
50. $v = 1.97 \times 10^8$ m/s $\lambda = 3.81 \times 10^{-7}$ m	$f = \frac{v}{\lambda} = \frac{1.97 \times 10^8 \text{ m/s}}{3.81 \times 10^{-7} \text{ m}} = \boxed{5.17 \times 10^{14} \text{ Hz}}$
51. $a_{g,moon} = 1.63$ m/s^2 $\Delta t = 24$ h $a_{g,Earth} = 9.81$ m/s^2	$T_{Earth} = 2\pi\sqrt{\frac{L}{a_{g,Earth}}}$ $T_{moon} = 2\pi\sqrt{\frac{L}{a_{g,moon}}}$ $\frac{T_{moon}}{T_{Earth}} = \sqrt{\frac{a_{g,Earth}}{a_{g,moon}}} = \sqrt{\frac{9.81 \text{ m/s}^2}{1.63 \text{ m/s}^2}} = 2.45$ The clock on the moon runs slower than the same clock on Earth by a factor of 2.45. Thus, after 24.0 h Earth time, the clock on the moon will have advanced by $\frac{24.0 \text{ h}}{2.45} = 9.80 \text{ h} = 9 \text{ h} + (0.80 \text{ h})(60 \text{ min/h}) = 9 \text{ h, } 48 \text{ min}$ Thus, the clock will read $\boxed{\text{9:48 A.M.}}$

Vibrations and Waves, Standardized Test Prep

2. $F = 7.0$ N $x = -0.35$ m	$F = -kx$ $k = -\frac{F}{x} = -\frac{(7.0 \text{ N})}{(-0.35 \text{ m})} = \boxed{2.0 \times 10^1 \text{ N/m}}$
6. $m = 48$ kg $k = 12$ N/m	$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{48 \text{ kg}}{12 \text{ N/m}}} = 2\pi \times 2 \text{ s} = \boxed{4\pi \text{ s}}$
9. $t = 2.0$ min	$f = 12 \text{ cycles}/120 \text{ s} = \boxed{0.10 \text{ Hz}}$

Givens	*Solutions*
10. $L = 2.00$ m $a_g = 9.80$ m/s^2 $\Delta t = 5.00$ min	$\text{oscillations} = \dfrac{\Delta t}{T} = \dfrac{\Delta t}{2\pi\sqrt{\dfrac{L}{a_g}}}$ $\text{oscillations} = \dfrac{(5.00 \text{ min})(60 \text{ s/min})}{(2\pi)\left(\sqrt{\dfrac{2.00 \text{ m}}{9.80 \text{ m/s}^2}}\right)}$ $\text{oscillations} = \boxed{106}$
16. $\lambda = 1.20$ m $f = \dfrac{8}{12.0 \text{ s}}$	$v = \lambda f = (1.20 \text{ m})\left(\dfrac{8}{12.0 \text{ s}}\right) = \boxed{0.800 \text{ m/s}}$
17. $\lambda = 5.20 \times 10^{-7}$ m $v = 3.00 \times 10^8$ m/s	$f = \dfrac{v}{\lambda} = \dfrac{3.00 \times 10^8 \text{ m/s}}{5.20 \times 10^{-7} \text{ m}} = \boxed{5.77 \times 10^{14} \text{ Hz}}$ $T = \dfrac{1}{f} = \dfrac{1}{5.77 \times 10^{14} \text{ Hz}} = \boxed{1.73 \times 10^{-15} \text{ s}}$
20. $T = 9.49$ s $a_g = g = 9.81$ m/s^2	$T = 2\pi\sqrt{\dfrac{L}{a_g}}$ $L = \dfrac{T^2 a_g}{4\pi^2} = \dfrac{(9.49 \text{ s})^2(9.81 \text{ m/s}^2)}{4\pi^2}$ $L = \boxed{22.4 \text{ m}}$
21. $f = \left(\dfrac{40.0}{30.0}\right)$ Hz $v = \left(\dfrac{425 \text{ cm}}{10.0 \text{ s}}\right) = \left(\dfrac{4.25}{10.0}\right)$ m/s	$\lambda = \dfrac{v}{f} = \dfrac{\left(\dfrac{4.25}{10.0}\right) \text{m/s}}{\left(\dfrac{40.0}{30.0}\right) \text{Hz}} = \boxed{0.319 \text{ m}}$

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