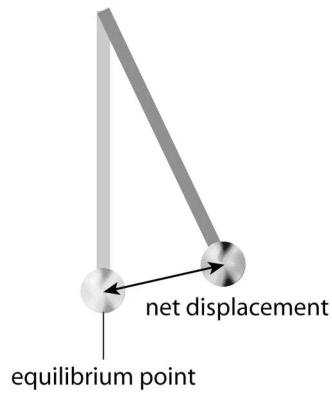
Chapter 8 Review, pages 408–413

Knowledge

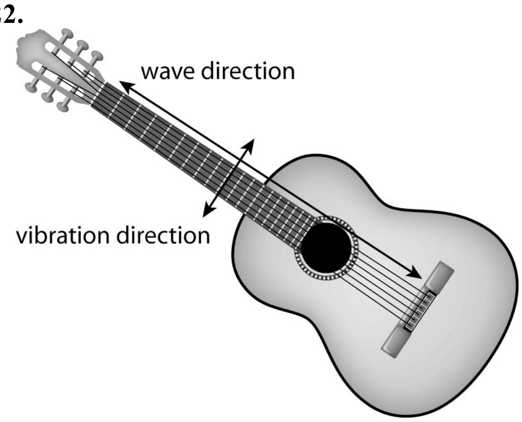
1. (b)
2. (c)
3. (d)
4. (a)
5. (c)
6. (b)
7. (c)
8. (a)
9. (b)
10. (d)
11. (d)
12. (c)
13. (a)
14. (a) (iv)
(b) (ii)
(c) (v)
(d) (iii)
(e) (i)
15. Answers may vary. Sample answer:
Three examples of waves that occur naturally are seismic waves, sound waves, and water waves.
16. As tension in the spring increases, the speed of the wave also increases.
17. The increase in pressure is caused by the collection of sound waves emitted by the aircraft that get closer and closer together as the aircraft approaches the speed of sound.
18. Answers may vary. Sample answer:
Noise pollution is the increase in loudness due to the sounds emitted by the surroundings. an example of noise pollution is the constant noise from cars on a nearby highway. This noise pollution can be reduced through construction of sound barriers along the highway or improvements to car engines.

Understanding

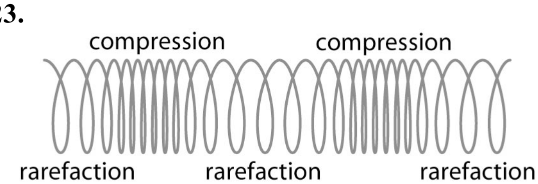
19.



20. Gases rely on translational molecular motion to transfer vibrations because gases have much lower density than liquids and solids and their gas molecules are much farther apart.
21. Vibrations are the cyclical motion of an object about an equilibrium point. Mechanical waves are the transfer of energy through a medium due to vibrations. Vibrations are the cause and waves are the effect.
22.



23.



24. Given: $T = 0.280$ s
Required: f

Analysis: $f = \frac{1}{T}$

Solution: $f = \frac{1}{T}$

$$= \frac{1}{0.280\ \text{s}}$$

$$f = 3.57\ \text{Hz}$$

Statement: The frequency of the pendulum is 3.57 Hz.

25. Given: $f = 82$ Hz
Required: T

Analysis: $f = \frac{1}{T}$

$$T = \frac{1}{f}$$

Solution: $T = \frac{1}{f}$

$$= \frac{1}{82\ \text{Hz}}$$

$$f = 0.012\ \text{s}$$

Statement: The period of the wave is 0.012 s.

26. Given: $\lambda = 0.620$ m; $T = 0.300$ s
Required: v

Analysis: $v = \frac{\lambda}{T}$

Solution: $v = \frac{\lambda}{T}$

$$= \frac{0.620\ \text{m}}{0.300\ \text{s}}$$

$$v = 2.07\ \text{m/s}$$

Statement: The speed of the wave is 2.07 m/s.

27. The amplitude of a longitudinal wave is defined as the maximum pressure it creates compared to the pressure of the non-disturbed medium.

28. (a) The wavelength is 5.4 cm and wave B is shifted 13.5 cm to the right of wave A.

$$\frac{13.5\ \cancel{\text{mm}}}{54\ \cancel{\text{mm}}} = 0.25$$

The phase shift is 0.25.

(b) The wavelength is 5.4 cm and wave B is shifted 13.5 cm to the left of wave A.

$$\frac{-13.5\ \cancel{\text{mm}}}{54\ \cancel{\text{mm}}} = -0.25$$

The phase shift is –0.25.

(c) The phase shift of B is half a wavelength. The phase shift is 0.5.

(d) The waves are in phase. The phase shift is 0.

29. Given: $f = 0.40$ Hz; $\lambda = 7.0$ m
Required: v
Analysis: $v = f\lambda$
Solution: $v = f\lambda$

$$= (0.40\ \text{Hz})(7.0\ \text{m})$$

$$v = 2.8\ \text{m/s}$$

Statement: The wave speed is 2.8 m/s.

30. Given: $v = 343.2$ m/s; $T = 0.00226$ s
Required: λ
Analysis: $v = f\lambda$

$$= \frac{\lambda}{T}$$

$$\lambda = vT$$

Solution: $\lambda = vT$

$$= \left(343.2\ \frac{\text{m}}{\cancel{\text{s}}}\right)(0.00226\ \cancel{\text{s}})$$

$$= 0.776\ \text{m}$$

$$\lambda = 77.6\ \text{cm}$$

Statement: The wavelength is 77.6 cm.

31. Given: $m = 0.180$ kg; $L = 1.60$ m
Required: μ

Analysis: $\mu = \frac{m}{L}$

Solution: $\mu = \frac{m}{L}$

$$= \frac{0.180\ \text{kg}}{1.60\ \text{m}}$$

$$\mu = 0.112\ \text{kg/m}$$

Statement: The linear density of the string is 0.112 kg/m.

32. Given: $\mu = 0.083$ kg/m; $L = 3.2$ m
Required: m

Analysis: $\mu = \frac{m}{L}$

$$m = \mu L$$

Solution: $m = \mu L$

$$= \left(0.083\ \frac{\text{kg}}{\cancel{\text{m}}}\right)(3.2\ \cancel{\text{m}})$$

$$m = 0.27\ \text{kg}$$

Statement: The mass of the string is 0.27 kg.

33. Given: $\mu = 0.19$ kg/m; $F_T = 184$ N
Required: v

Analysis: $v = \sqrt{\dfrac{F_T}{\mu}}$

Solution:
$$\begin{aligned} v &= \sqrt{\frac{F_T}{\mu}} \\ &= \sqrt{\frac{184\ \text{N}}{0.19\ \text{kg/m}}} \\ &= \sqrt{\frac{184\ \dfrac{\cancel{\text{kg}}\bullet\text{m}}{s^2}}{0.19\ \dfrac{\cancel{\text{kg}}}{\text{m}}}} \\ v &= 31\ \text{m/s} \end{aligned}$$

Statement: The speed of a wave along the string is 31 m/s.

34. Given: $F_T = 100.0$ N; $v = 40.0$ m/s
Required: μ

Analysis:
$$\begin{aligned} v &= \sqrt{\frac{F_T}{\mu}} \\ v^2 &= \frac{F_T}{\mu} \\ \mu &= \frac{F_T}{v^2} \end{aligned}$$

Solution:
$$\begin{aligned} \mu &= \frac{F_T}{v^2} \\ &= \frac{100.0\ \text{N}}{(40.0\ \text{m/s})^2} \\ &= \frac{100.0\ \dfrac{\text{kg}\bullet\cancel{\text{m}}}{\cancel{s^2}}}{1600\ \dfrac{\text{m}^{\cancel{2}}}{\cancel{s^2}}} \\ \mu &= 6.25\times10^{-2}\ \text{kg/m} \end{aligned}$$

Statement: The linear density of the string is 6.25×10^{-2} kg/m, or 0.0625 kg/m.

35. Tightening the machine head increases the tension on the spring. As the tension increases, the wave speed increases. Likewise, loosening the machine head reduces the tension, which reduces the wave speed.

36. Waves generally travel faster in rigid media because the rigid intermolecular forces allow for a faster transfer of energy.

37. Given: $T = 18$ °C
Required: v

Analysis: $v = 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})T$

Solution:
$$\begin{aligned} v &= 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})T \\ &= 331.4\ \text{m/s} + \left(0.606\ \frac{\text{m/s}}{\cancel{\text{°C}}}\right)(18\ \cancel{\text{°C}}) \\ &= 331.4\ \text{m/s} + 10.9\ \text{m/s} \\ &= 342.3\ \text{m/s} \\ v &= 340\ \text{m/s} \end{aligned}$$

Statement: The speed of sound in 18 °C air is 340 m/s.

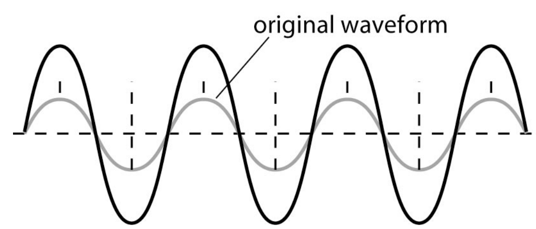
38. Given: $v = 349$ m/s
Required: T

Analysis: $v = 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})T$
$$T = \frac{v - 331.4\ \text{m/s}}{0.606\ \text{m/s/°C}}$$

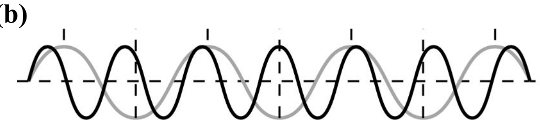
Solution:
$$\begin{aligned} T &= \frac{v - 331.4\ \text{m/s}}{0.606\ \text{m/s/°C}} \\ &= \frac{349\ \text{m/s} - 331.4\ \text{m/s}}{0.606\ \text{m/s/°C}} \\ &= \frac{17.6\ \cancel{\text{m/s}}}{0.606\ \dfrac{\cancel{\text{m/s}}}{\text{°C}}} \\ T &= 29.0\ \text{°C} \end{aligned}$$

Statement: The ambient temperature is 29.0 °C.

39. (a)



(b)



40. Given: $v_{sound} = 313$ m/s; $v_{aircraft} = 907$ km/h
Required: M

Analysis: $M = \dfrac{v_{aircraft}}{v_{sound}}$

Solution:
$$\begin{aligned} M &= \frac{v_{aircraft}}{v_{sound}} \\ &= \frac{907\ \text{km/h}}{313\ \text{m/s}} \\ &= \frac{907\ \dfrac{\cancel{\text{km}}}{\cancel{\text{h}}}}{313\ \dfrac{\cancel{\text{m}}}{\cancel{s}}}\left(\frac{1000\ \cancel{\text{m}}}{1\ \cancel{\text{km}}}\right)\left(\frac{1\ \cancel{\text{h}}}{3600\ \cancel{s}}\right) \\ M &= 0.805 \end{aligned}$$

Statement: The Mach number is 0.805.

41. Given: $v_{sound} = 300.0$ m/s; $M = 0.481$

Required: $v_{airplane}$

Analysis: $M = \frac{v_{airplane}}{v_{sound}}$

$$v_{airplane} = Mv_{sound}$$

Solution:

$$\begin{aligned} v_{airplane} &= Mv_{sound} \\ &= (0.481)(300.0 \text{ m/s}) \\ &= 144.3 \text{ m/s} \\ &= \left(144.3 \frac{\text{m}}{\text{s}}\right)\left(\frac{1 \text{ km}}{1000 \text{ m}}\right)\left(\frac{3600 \text{ s}}{1 \text{ h}}\right) \\ v_{airplane} &= 519 \text{ km/h} \end{aligned}$$

Statement: The speed of the airplane is 519 km/h.

42. Loudness is expressed in a logarithmic scale using decibels (dB). Decibels are a more convenient measurement unit than watts per square metre (W/m^2). The watt per square metre values for loudness can vary from 1.0×10^{-12} (the threshold of human hearing) to 1.0×10^{13} (an atomic bomb).

43. Answers may vary. Sample answer:
Aircraft were used to break the sound barrier. There are no forces of friction to slow down an aircraft unlike a car (which is dependent on wheels rolling on the ground).

Analysis and Application

44. Answers may vary. Sample answer:
I do not think you would hear any sound because there is no air in space for sound waves to travel through.

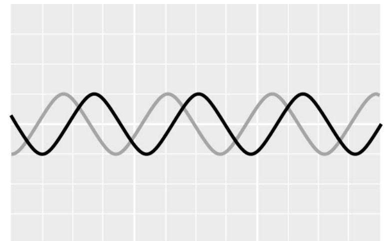
45. (a) Students should indicate the top of the wave on the right.

(b) Students should indicate the distance between the middle dotted line and either a crest or a trough.

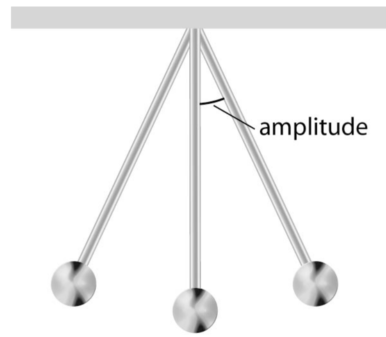
(c) Students should indicate the distance between a consecutive pair of waves.

(d) Students should indicate the bottom of the curve below the equilibrium, at the centre, as the trough.

46. Since each square represents 0.25 m, the new wave is shifted one square to the right:



47.



48. Given: $\lambda = 82$ cm $= 0.82$ m; $v = 540$ m/s

Required: f

Analysis: $v = f\lambda$

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

Solution:

$$\begin{aligned} f &= \frac{v}{\lambda} \\ &= \frac{540 \frac{\text{m}}{\text{s}}}{0.82 \text{ m}} \\ f &= 6.6 \times 10^2 \text{ Hz} \end{aligned}$$

Statement: The frequency of the wave is 6.6×10^2 Hz, or 660 Hz.

49. Given: $v = 62$ m/s; $L = 0.60$ m; $F_T = 200$ N

Required: m

Analysis: $v = \sqrt{\frac{F_T}{\mu}}$

$$\begin{aligned} v^2 &= \frac{F_T}{\mu} \\ \mu &= \frac{F_T}{v^2} \\ \mu &= \frac{m}{L} \\ m &= \mu L \\ m &= \frac{F_T}{v^2} L \end{aligned}$$

Solution:

$$m = \frac{F_T}{v^2}L$$
$$= \frac{200\text{ N}}{(62\text{ m/s})^2}(0.60\text{ m})$$
$$= \frac{200\ \frac{\text{kg}\bullet\cancel{\text{m}}}{\cancel{\text{s}^2}}}{3844\ \frac{\cancel{\text{m}^2}}{\cancel{\text{s}^2}}}(0.60\ \cancel{\text{m}})$$
$$m = 3.1\times10^{-2}\text{ kg}$$

Statement: The mass of the string is 3.1×10^{-2} kg or 31 g.

50. Given: m = 0.220 kg; L = 4.30 m; v = 18.0 m/s

Required: F_T

Analysis: $v = \sqrt{\frac{F_T}{\mu}}$

$$v^2 = \frac{F_T}{\mu}$$
$$F_T = \mu v^2$$
$$F_T = \left(\frac{m}{L}\right)v^2$$

Solution: $F_T = \left(\frac{m}{L}\right)v^2$

$$= \frac{0.220\text{ kg}}{4.30\text{ m}}(18.0\text{ m/s})^2$$
$$= \frac{0.220\text{ kg}}{4.30\ \cancel{\text{m}}}\left(324.00\ \frac{\text{m}^{\cancel{2}}}{\text{s}^2}\right)$$
$$F_T = 16.6\text{ N}$$

Statement: The tension in the string is 16.6 N.

51. Given: f_E = 329.6 Hz; λ = 1.032 m; m = 180.0 mg = 0.000 18 kg; L = 32.0 cm = 0.320 m; f = 328.1 Hz

Required: ΔF_T

Analysis: $v = \sqrt{\frac{F_T}{\mu}}$

$$v^2 = \frac{F_T}{\mu}$$
$$F_T = \mu v^2$$
$$= \left(\frac{m}{L}\right)(f\lambda)^2$$
$$F_T = \frac{mf^2\lambda^2}{L}$$

Solution: Determine the current tension:

$$F_T = \frac{mf^2\lambda^2}{L}$$
$$= \frac{(0.000\ 18\text{ kg})(328.1\text{ Hz})^2(1.032\text{ m})^2}{0.320\text{ m}}$$
$$F_T = 64.49\text{ N}$$

Determine the tension required for an E:

$$F_{TE} = \frac{mf_E^2\lambda^2}{L}$$
$$= \frac{(0.000\ 18\text{ kg})(329.6\text{ Hz})^2(1.032\text{ m})^2}{0.320\text{ m}}$$
$$F_{TE} = 65.08\text{ N}$$

Determine the difference in tension:

$$\Delta F_T = F_{TE} - F_T$$
$$= 65.08\text{ N} - 64.49\text{ N}$$
$$\Delta F_T = 0.59\text{ N}$$

Statement: You need to increase the tension by 0.59 N.

52. Given: v = 1496 m/s

Required: T

Analysis: $v = 331.4\text{ m/s} + (0.606\text{ m/s/°C})T$

$$T = \frac{v - 331.4\text{ m/s}}{0.606\text{ m/s/°C}}$$

Solution: $T = \frac{v - 331.4\text{ m/s}}{0.606\text{ m/s/°C}}$

$$= \frac{1496\text{ m/s} - 331.4\text{ m/s}}{0.606\text{ m/s/°C}}$$
$$= \frac{1164.6\ \cancel{\text{m/s}}}{0.606\ \frac{\cancel{\text{m/s}}}{\text{°C}}}$$
$$T = 1922\text{ °C}$$

Statement: The air temperature would need to be 1922 °C.

53. Given: $v_{aircraft}$ = 48.3 km/h; M = 0.040

Required: T

Analysis: $v_{sound} = 331.4\text{ m/s} + (0.606\text{ m/s/°C})T$ **;**

$$M = \frac{v_{airplane}}{v_{sound}}$$
$$v_{sound} = \frac{v_{airplane}}{M}$$

Solution: Determine the speed of the sound:

$$v_{\text{sound}} = \frac{v_{\text{airplane}}}{M}$$

$$= \frac{48.3\ \frac{\text{km}}{\text{h}}}{0.040}\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)$$

$$= 335.4\ \text{m/s}\ \ \text{(one extra digit carried)}$$

$$v_{\text{sound}} = 335\ \text{m/s}$$

Determine the temperature:

$$v_{\text{sound}} = 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})T$$

$$T = \frac{v_{\text{sound}} - 331.4\ \text{m/s}}{0.606\ \text{m/s/°C}}$$

$$T = \frac{335.4\ \text{m/s} - 331.4\ \text{m/s}}{0.606\ \frac{\text{m/s}}{\text{°C}}}$$

$$T = 6.6\ \text{°C}$$

Statement: The air temperature is 6.6 °C.

54. Given: $T = -56.0$ °C; $M = 3.00$

Required: v_{airplane}

Analysis: $M = \frac{v_{\text{airplane}}}{v_{\text{sound}}}$

$$v_{\text{airplane}} = Mv_{\text{sound}}$$

Solution: Determine the local speed of sound:

$$v_{\text{sound}} = 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})T$$

$$= 331.4\ \text{m/s} + \left(0.606\ \frac{\text{m/s}}{\text{°C}}\right)(-56.0\ \text{°C})$$

$$= 331.4\ \text{m/s} - 33.936\ \text{m/s}$$

$$= 297.46\ \text{m/s}$$

$$v_{\text{sound}} = 297\ \text{m/s}$$

Determine the speed of the aircraft:

$$v_{\text{airplane}} = Mv_{\text{sound}}$$

$$= (3.00)(297.46\ \text{m/s})$$

$$= 892.38\ \text{m/s}$$

$$= \left(892.38\ \frac{\text{m}}{\text{s}}\right)\left(\frac{1\ \text{km}}{1000\ \text{m}}\right)\left(\frac{3600\ \text{s}}{1\ \text{h}}\right)$$

$$= 3213.6\ \text{km/h}$$

$$v_{\text{airplane}} = 3210\ \text{km/h}$$

Statement: The speed of the airplane is 3210 km/h.

55. Answers may vary. Sample answer:
Without a medium, visual communication would be very useful. Some methods include writing, semaphore, and blinking lights in Morse code. Radio waves are a non-visual method of communication that work without a medium.

56. Answers may vary. Sample answer:
As propeller planes approach the speed of sound, the propellers lose effectiveness due to increased drag on the propeller blades. This requires that the propeller blades be travelling at a speed much greater than the speed of sound. The blades may also have difficulty with the change in pressure near the speed of sound.

57. Answers may vary. Sample answer:
Quartz clocks are still subject to temperature, but are more accurate than a mechanical watch.

58. Answers may vary. Students should have a journal of the sounds they hear during a day. Decibel levels will have to be estimated (unless sound meters are available) and may not be accurate, but the student should get an idea of the amount of sound they interact with on a daily basis.

59. Answers may vary. Sample answer:
When a musical instrument like a guitar or a piano is not tuned properly, the sound it makes will not be quite right. The tension of the strings needs to be adjusted to get the right sound.

Evaluation

60. (a) Given: $T_1 = 5.40$ °C; $T_2 = 26.4$ °C; $\Delta t = 0.5(0.250\ \text{s}) = 0.125$ s

Required: Δd

Analysis: $\Delta d = d_2 - d_1$

Solution: Determine the speed of sound at T_1:

$$v_{\text{sound1}} = 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})T_1$$

$$= 331.4\ \text{m/s} + \left(0.606\ \frac{\text{m/s}}{\text{°C}}\right)(5.40\ \text{°C})$$

$$= 331.4\ \text{m/s} + 3.2724\ \text{m/s}$$

$$= 334.67\ \text{m/s}$$

$$v_{\text{sound1}} = 335\ \text{m/s}$$

Determine the speed of sound at T_2:

$$v_{\text{sound2}} = 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})T_2$$

$$= 331.4\ \text{m/s} + \left(0.606\ \frac{\text{m/s}}{\text{°C}}\right)(26.4\ \text{°C})$$

$$= 331.4\ \text{m/s} + 15.998\ \text{m/s}$$

$$= 347.40\ \text{m/s}$$

$$v_{\text{sound2}} = 347\ \text{m/s}$$

Determine the distance at v_{sound1}:

$$d_1 = v_{sound1}\Delta t$$
$$= (334.67 \text{ m/s})(0.125 \text{ s})$$
$$d_1 = 41.8 \text{ m}$$

Determine the distance at v_{sound2}:

$$d_2 = v_{sound1}\Delta t$$
$$= (347.40 \text{ m/s})(0.125 \text{ s})$$
$$d_2 = 43.4 \text{ m}$$

Statement: The range of distances from camera to subject is 41.8 m to 43.4 m.
(b) Answers may vary. Sample answer:
This difference in distance seems reasonable for a camera since the camera won't focus too differently for 40 m versus 50 m distances.
(c) Answers may vary. Sample answer:
No, I would want a much smaller range of error if measuring smaller distances.

Reflect on Your Learning

61. Answers may vary. Sample answer:
Sound is energy. I hadn't thought of sound in that way before.
62. Answers may vary. Sample answer:
I have a basic understanding now. I did not know that sound travels at different speeds in different media, and that there are different frequencies of sound.
63. Answers may vary. Sample answer:
I do not know if loud sound is really an issue. My hearing seems fine to me. OR I do not want to lose my hearing, so I think I will adjust my volume level when listening to my iPod.

Research

64. Answers may vary. Students' answers should indicate that sonograms allow doctors to examine soft tissue without having to operate on a patient. Sonograms are used to make images of muscles, tendons, breasts, liver, kidneys, brains, hearts, and other soft tissue in the body.
65. Answers may vary. Students' answers could include two of the following advantages of wave power: free, inexpensive, and renewable. Two disadvantages of wave power are the need for a consistent site and the variability of weather.
66. Answers may vary. Students' answers should indicated that ultrasound waves are used to determine the location of the stones. Then, high-energy sound waves are directed at the stones to break them into smaller, less invasive pieces that the body can flush out. Detailed descriptions of the physics behind this technology could be provided.
67. Answers may vary. Students' answers might include possible unaccredited flights that broke the sound barrier before Chuck Yeager; answers could include Thrust SSC setting the land speed record by breaking the sound barrier in 1997.
68. Answers may vary.
(a) Sample answer: Some animals that use infrasonic waves are whales, elephants, and giraffes.
(b) Students' answers should indicate that infrasonic waves allow animals to communicate over long distances especially when transmitted through a solid or liquid medium. For example, whales use infrasonic waves to communicate through hundreds of kilometres of ocean, and elephants can detect the waves transmitted through the ground. The early response by animals to natural disasters such as earthquakes and tsunamis may be because they can detect infrasonic waves that humans cannot detect.
69. Answers may vary. Students may include tornado detection, oil or gas leak detection, or arms testing detection.
70. Answers may vary. Historical string instruments include the harp, lute, lyre, rebab, sitar, erhu, and koto. The graphic organizer could be a table, t-chart, tree branch diagram, or other organizer.
71. (a) Descriptions should be similar to the following: Ultrasonic welding uses high-frequency vibrations to cause a tiny amount of melting at the joint of two materials.
(b) Answers may vary. Student answers should be similar to the following: Ultrasonic welding is used to manufacture a variety of medical and computer components, as well as plastic car parts and ordinary plastic containers that need to be airtight.
72. Answers may vary. Students' answers should include the following information:
The Wright brothers and others flew gliders before the first credited flight in 1903. One of the big hurdles to powered, manned flight was three axial control. The reports should compare the Wright Flyer I to other airplanes of this period. A comparison of the mechanical advantages and disadvantages between the Flyer I and other airplanes could be presented in a graphic organizer.