Q1.

A transverse wave on a string with a linear density of 0.200 kg/m is described by the following equation: y = 0.005 sin(419 t – 21.0 x), where x and y are in meters and t is in seconds. What is the tension in the string?

A) 79.6 N
B) 3.99 N
C) 42.1 N
D) 32.5 N
E) 65.8 N

Ans:

$$\mathrm{v} = \frac{\omega}{k} = \frac{419}{21.0}$$

$$\mathrm{v} = \sqrt{\frac{\tau}{\mu}}$$

$$\Rightarrow \mathrm{v} = \mu \mathrm{v}^2$$

$$\therefore\ \tau = 0.200 \times \left(\frac{419}{21.0}\right)^2 = 79.6\ \mathrm{N}$$

Q2.

A stone is dropped into a lake; and it produces circular surface waves with a frequency of 0.25 Hz. When should a second stone be dropped, after the first, at the same place to produce destructive interference? Ignore the time it takes the stone to reach water.

A) 2.0 s
B) 1.0 s
C) 0.75 s
D) 0.50 s
E) 1.5 s

Ans:

$$\mathrm{f} = \frac{1}{4}\ \mathrm{Hz} \rightarrow \mathrm{T} = \frac{1}{\mathrm{f}} = 4\ \mathrm{s}$$

$$\left.\begin{matrix} 2\pi \rightarrow \mathrm{T} \\ \phi \rightarrow \mathrm{t} \end{matrix}\right\} \rightarrow \mathrm{t} = \frac{\phi.\mathrm{T}}{2\pi} = \frac{\pi.\mathrm{T}}{2\pi} = \frac{\mathrm{T}}{2} = 2.0\ \mathrm{s}$$

Q3.

Which one of the following statements is **TRUE** concerning the points on a string that sustains a standing wave pattern?

A) The amplitude of oscillation is not the same for all points.
B) All points vibrate vertically with the same speed.
C) All points undergo the same displacements.
D) All points vibrate with different frequencies.
E) Some points undergo motion that is purely longitudinal.

Ans:

A

Q4.

A string with a length of 2.5 m, fixed at both ends, has two successive resonances at frequencies of 112 Hz and 140 Hz. Determine the wavelength of the 140 Hz resonance.

A) 1.0 m
B) 0.50 m
C) 2.0 m
D) 0.75 m
E) 1.5 m

Ans:

$$f_1 = \Delta f = 140 - 112 = 28 \text{ Hz}$$

$$f_n = nf_1 \Rightarrow n = \frac{f_n}{f_1} = \frac{140}{28} = 5$$

$$\lambda_n = \frac{2L}{n} = \frac{2 \times 2.5}{5} = 1.0 \text{ m}$$

Q5.

Two transmitters, S1 and S2, shown in **Figure 1**, emit identical sound waves at a frequency of 680 Hz. The transmitters are separated by a distance of 2.0 m. Consider a big circle of radius *R* with its center halfway between these transmitters. How many interference minima are there on this big circle? Take the speed of sound in air to be 340 m/s.

A) 16
B) 4
C) 8
D) 3
E) 12

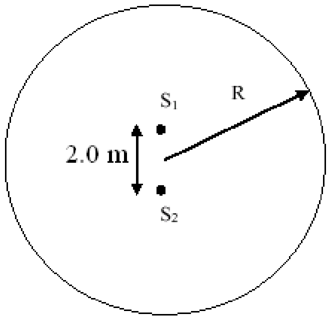


Figure 1

Ans:

$$\lambda = \frac{v}{f} = \frac{340}{680} = 0.50 \text{ m}$$

$$D = 2.0 \text{ m} \quad \Rightarrow D = 4\lambda$$

$$\therefore \text{The minima in the first quadrant correspond to: } \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \frac{7\lambda}{2} \Rightarrow 4 \text{ minima}$$

$$\therefore \text{On the big circle: } 4 \times 4 = 16 \text{ minima}$$

Q6.

During a typical workday of eight hours, the average sound intensity arriving at a human ear is 1.8×10^{-5} W/m^2. If the area of the human ear through which the sound passes is 2.1 cm^2, what is the total energy entering each ear during the workday?

A) 1.1×10^{-4} J
B) 1.8×10^{-5} J
C) 7.4×10^{-4} J
D) 4.1×10^{-3} J
E) 2.2×10^{-4} J

Ans:

$$I = \frac{P}{A} \Rightarrow P = IA$$

$$E = P.t = IAt = 1.8 \times 10^{-5} \times 2.1 \times 10^{-4} \times 8 \times 3600 = 1.1 \times 10^{-4} \text{ J}$$

Q7.

A tube closed at one end resonates in the standing wave pattern shown in **Figure 2**. If the length of the tube is 0.500 m, and the speed of sound in air is 343 m/s, what is the frequency of the emitted sound?

A) 858 Hz
B) 429 Hz
C) 515 Hz
D) 343 Hz
E) 172 Hz

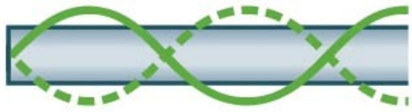


Figure 2

Ans:

The figure corresponds to the fifth mode (n = 5)

$$f_n = \frac{nv}{4\,L} \;\Rightarrow\; f_5 = \frac{5 \times 343}{4 \times 0.500} = 858\text{ Hz}$$

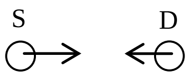
Q8.

Two cars are traveling in opposite directions at the same speed when one of the drivers sounds the horn of his car, which has a frequency of 544 Hz. The other driver hears the frequency as 563 Hz. If the speed of sound in air is 344 m/s, what is the speed of the cars?

A) 5.90 m/s
B) 8.19 m/s
C) 11.6 m/s
D) 7.24 m/s
E) 10.0 m/s

Ans:

$$f' = f.\frac{v + x}{v - x} \quad \{x\text{: speed of cars}\}$$



$$\alpha = \frac{v + x}{v - x} \;\Rightarrow\; \alpha\,v - v = \alpha\,x + x \;\left\{\alpha = \frac{f'}{f}\right\}$$

$$\Rightarrow x = \frac{\alpha - 1}{\alpha + 1}\,.\,v = \frac{1.04 - 1}{1.04 + 1} \times 344 = 5.90\text{ m/s}$$

Q9.

At 20 ^{o}C, an aluminum cube has an edge length of 25 cm. What is the increase in the cube's total surface area when it is heated from 20 ^{o}C to 75 ^{o}C. The coefficient of linear expansion of aluminum is 23×10^{-6}/C°.

A) 9.5 cm^2
B) 1.6 cm^2
C) 6.3 cm^2
D) 13 cm^2
E) 4.7 cm^2

Ans:

One face: $\Delta A^{*} = 2\,\alpha\, A\, \Delta\, T$

total: $\Delta A = 6\,\Delta A^{*} = 12\,\alpha\, A\, \Delta\, T$

$= 12 \times 23 \times 10^{-6} \times 625 \times 55 = 9.5\ \mathrm{cm}^2$

Q10.

A 0.0400-kg ice cube at 0.00 °C is placed in an insulated box that contains 0.0750 kg of water at 100 °C. What is the equilibrium temperature reached by this closed system?

A) 37.6 °C
B) 65.2 °C
C) 50.7 °C
D) 33.6 °C
E) 22.7 °C

Ans:

$Q_1 = m_i L_f = 0.04 \times 3.33 \times 10^5 = 13320\ \mathrm{J}$

$Q_2 = m_i . C_W . \Delta T = 0.04 \times 4190 \times (T_f - 0) = 167.6\, T_f$

$Q_3 = m_w C_W . \Delta T = 0.075 \times 4190 \times (T_f - 100) = 314.25 T_f - 31425$

$Q_1 + Q_2 + Q_3 = 0: 481.85\, T_f = 18105 \Rightarrow T_f = 37.6\ °\mathrm{C}$

Q 11.

A wall has a thickness of 0.61 m and a thermal conductivity of 2.1 W/(mC°). The temperature on one face of the wall is 3.2 °C, and 20.0 °C on the opposite face. How much heat is transferred in one hour through each square meter of the wall?

A) 2.1×10^5 J
B) 7.7×10^4 J
C) 58 J
D) 1.0×10^5 J
E) 1.8×10^3 J

Ans:

$$P_{Cond} = \frac{k.A.\Delta T}{L} = \frac{2.1 \times 1.0 \times (20 - 3.2)}{0.61} = 57.8\ \mathrm{W}$$

$Q = P_{Cond} . t = 57.8 \times 1 \times 3600$

$= 2.1 \times 10^5\ \mathrm{J}$

Q 12.

A system containing an ideal gas at a constant pressure of 1.22×10^5 Pa gains 2500 J of heat. During the process, the internal energy of the system increases by 2320 J. What is the change in the volume of the gas?

A) $+1.48 \times 10^{-3}$ m^3
B) -1.48×10^{-3} m^3
C) $+3.66 \times 10^{-3}$ m^3
D) zero
E) -3.66×10^{-3} m^3

Ans:

$$\Delta E_{int} = Q - W$$

$$W = Q - \Delta E_{int}$$

$$P\Delta V = Q - \Delta E_{int}$$

$$\therefore \Delta V = \frac{Q - \Delta E_{int}}{P} = \frac{2500 - 2320}{1.22 \times 10^5} = +1.48 \times 10^{-3} m^3$$

Q13.

Which one of the following properties of a gas is **NOT** consistent with the kinetic theory of gasses?

A) The average speed of the gas molecules is <u>smaller</u> at <u>higher</u> temperatures.
B) Gas molecules are widely separated.
C) Gases fill whatever space is available to them.
D) Gas molecules move rapidly in a random fashion.
E) Gas molecules make elastic collisions with the walls of the container.

Ans:

A

Q14.

A container having 150 kg of an ideal gas has a volume of 8.00 m^3. If the gas exerts a pressure of 5.00×10^5 Pa, what is the rms speed of the molecules?

A) 283 m/s
B) 165 m/s
C) 354 m/s
D) 420 m/s
E) 397 m/s

Ans:

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3}{M} \cdot \frac{pV}{n}} = \sqrt{\frac{3pV}{M_{Sample}}}$$

$$= \sqrt{\frac{3 \times 5.00 \times 10^5 \times 8.00}{150}} = 283 \text{ m/s}$$

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Ans:

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$$= \sqrt{\frac{3 \times 5.00 \times 10^5 \times 8.00}{150}} = 283 \text{ m/s}$$

Q17.

An ideal monatomic gas contains 5.00 moles. The pressure of the gas is doubled at constant volume. How much is the change in the entropy of the gas?

A) + 43.2 J/K
B) – 43.2 J/K
C) – 72 J/K
D) + 72 J/K
E) zero

Ans:

$$\Delta S = \int \frac{dQ}{T} = \int \frac{nC_v dT}{T} = nC_v \ln\left(\frac{T_f}{T_i}\right) = n.C_v.\ln\left(\frac{P_f}{P_i}\right)$$

$$= 5.00 \times 1.5 \times 8.31 \times \ln(2) = +43.2\ \frac{J}{K}$$

Q18.

A heat engine operates between a hot reservoir at 1500 K and a cold reservoir at 500 K. During each cycle, 1.0×10^5 J of heat is removed from the hot reservoir and 5.0×10^4 J of work is performed. The actual efficiency of this engine is:

A) 75 % of the maximum efficiency
B) 67 % of the maximum efficiency
C) 50 % of the maximum efficiency
D) 17 % of the maximum efficiency
E) 87 % of the maximum efficiency

Ans:

$$\varepsilon_{ideal} = 1 - \frac{T_L}{T_M} = 1 - \frac{500}{1500} = \frac{2}{3}$$

$$\varepsilon_{real} = \frac{W}{Q_H} = \frac{5.0 \times 10^4}{10 \times 10^4} = \frac{1}{2}$$

$$\frac{\varepsilon_{real}}{\varepsilon_{ideal}} = \frac{1}{2} \times \frac{3}{2} = \frac{3}{4} = 75\%$$

Q19.

A Carnot refrigerator is placed in a kitchen. The temperature inside the refrigerator is 2.0 °C, and the temperature of the kitchen is 22 °C. The rate of heat flow from the refrigerator to the kitchen is 24.7 kW. What power is needed to operate this refrigerator?

A) 1.8 kW
B) 3.6 kW
C) 2.5 kW
D) 4.7 kW
E) 0.4 kW

Ans:

$$K = \frac{T_L}{T_H - T_L} = \frac{275.15}{22} = 13.75$$

$$K = \frac{Q_L}{W} \Rightarrow W = \frac{Q_L}{K} = \frac{24.7}{13.75} = 1.8\text{ kW}$$

Q20.

A system consists of two thermal reservoirs in contact with each other, one at a temperature of 300 ^oC and the other at a temperature of 200 ^oC. If 6000 J of heat is transferred from the 300 ^oC reservoir to the 200 ^oC reservoir, what is the change in entropy of this system?

A) +2.2 J/K
B) +13 J/K
C) -10 J/K
D) +10 J/K
E) -2.2 J/K

Ans:

$$\Delta S_1 = \frac{Q}{T_1} = +\frac{6000}{200 + 273} = +12.7\ \frac{J}{K}$$

$$S_2 = \frac{Q}{T_2} = -\frac{6000}{300 + 273} = -10.5\ \frac{J}{K}$$

$$\Rightarrow \Delta S = \Delta S_1 + \Delta S_2 = +2.2\ \frac{J}{K}$$
