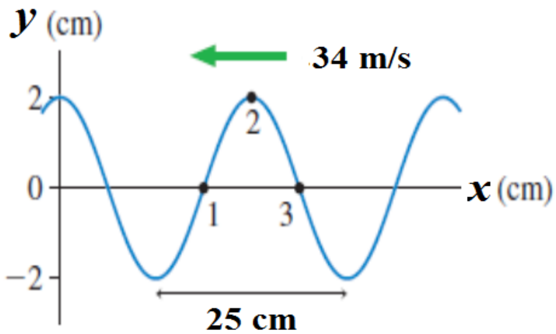
Q1.
Figure 1 shows a graph of a wave traveling to the left along a string at a speed of 34 m/s. At this instant, what is the transverse velocity of points 1, 2, and 3, respectively, on the string?

Fig#



A) +17 m/s, 0 m/s, −17 m/s
B) −17 m/s, +17 m/s, 0 m/s
C) +17 m/s, −17 m/s, 0 m/s
D) −19 m/s, 0 m/s, +19 m/s
E) +19 m/s, −19 m/s, 0 m/s

Q2.
Two pieces of string, each of length L=1.5 m, are joined together end to end, to make a 3.0 m long combined string. The first piece of string has mass per unit length μ_1=100 g/m, the second piece has mass per unit length $\mu_2 = 6.0\ \mu_1$. If the combined string is under tension $\tau = 5.0$ N, how much time does it take a transverse travelling wave to travel the entire 3.0 m length of the string?

A) 0.73 s
B) 1.1 s
C) 1.7 s
D) 1.9 s
E) 2.8 s

Q3.
Which one of the following transverse waves traveling in the same string transports the maximum power?

A) a wave with velocity 2v, amplitude A/2, and frequency 2f
B) a wave with velocity v, amplitude 2A, and frequency f/2
C) a wave with velocity 2v, amplitude A/2, and frequency f
D) a wave with velocity 2v, amplitude A, and frequency f/2
E) a wave with velocity v, amplitude A, and frequency f

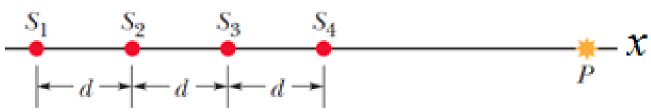
Q4.
A string oscillates in a third -harmonic standing wave pattern. The amplitude at a point

30 cm from one end of the string is half the maximum amplitude. How long is the string?

A) 5.4 m
B) 4.2 m
C) 6.0 m
D) 6.4 m
E) 7.2 m

Q5.
Figure 2 shows four isotropic identical in-phase point sound sources S1, S2, S3, and S4 located along x-axis. The sounds from the four sources interfere at point *P,* located on the *x* axis Assume that as the sound waves travel to *P*, the decrease in their amplitude is negligible. If distance $d = \lambda/4$ which of the following statement is **True**.

Fig#



A) Sound from S1 and S3 interfere destructively at P.
B) Sound from S2 and S4 interfere destructively and from S1 and S3 interfere constructively, at P.
C) Sound from S2 and S4 interfere constructively at P.
D) Sound from S1 and S3 interfere constructively and from S2 and S4 interfere constructively at P.
E) None of the given answers

Q6.
Standing waves of sound are set up in a vertical tube of length 1.000 m with both ends open, filled with air. The tube has a fundamental frequency $f_{0\text{-}air}$. Then the bottom end of the tube is closed and filled completely with a fluid. The fundamental frequency of the tube filled with the fluid is $f_{0\text{-}fluid}$. Find the fundamental frequency ratio $f_{0\text{-}fluid} / f_{0\text{-}air}$ (speed of sound in air = 343.0 m/s and speed of sound in the fluid is 1482 m/s).

A) 2.160
B) 1.123
C) 1.505
D) 2.789
E) 3.545

Q7.
A sound meter placed 3 m from a point isotropic sound source measures a sound level of 70 dB. If the power of the sound source is reduced by a factor of 20, what will be the sound meter reading?

A) 57 dB
B) 11 dB

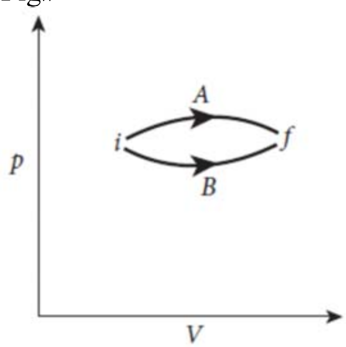
C) 25 dB
D) 32 dB
E) 66 dB

Q8.
A stationary observer is standing between two sound sources A and B. Source A is moving away from the observer, and source B is moving toward the observer. Both sources emit sound of the same frequency. If both sources are moving with a speed $v_{sound}/2$, what is the ratio of the frequencies f_B / f_A detected by the observer?(Assume speed of sound v_{sound} = 343 m/s)

A) 3
B) 4
C) 5
D) 6
E) 7

Q9.
An ideal gas system can go from state *i* to state *f through process A or B,* as shown in the **Figure 3**. If W_A, W_B, Q_A and Q_B are work done and heat exchanged during processes A and B, respectively, which of the following relations is **True**?

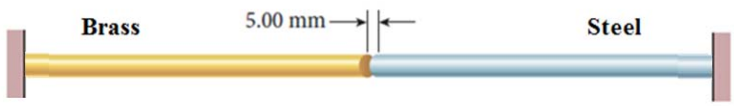
Fig#



A) $Q_A > Q_B$
B) $Q_A = Q_B$
C) $Q_A < Q_B$
D) $W_A=W_B$
E) $W_B >W_A$

Q10.
The ends of the two brass and steel rods, each 1.00 m long; as shown in the **Figure 4**, are separated by 5.00 mm at 25.0 °C. Assuming that the outside ends of both rods rest firmly against rigid supports, at what temperature will the inside ends of the rods just touch? (α_{steel}=13.0 × 10^{-6} / °C ; α_{Brass}=19.0 × 10^{-6} /C°).

Fig#



A) 181 °C
B) 157 °C
C) 291 °C
D) 399 °C
E) 401 °C

Q11.
A 150 g of water at 30.0 °C is poured over a 60.0 g cube of ice at a temperature of –5.00 °C. How many gram of ice has melted when the ice-water mixture has reached thermal equilibrium (specific heat of ice c_{ice} = 2220 J/kg.K; heat of fusion of ice L_F =333 kJ/kg)?

A) 54.6 g
B) 47.5 g
C) 50.0 g
D) 57.0 g
E) 59.0 g

Q12.
A tea pot, with a 8.500 mm thick steel bottom plate, rests on a hot stove. The area of the bottom plate is 0.1500 m^2. The water inside the pot is at 100.0 °C, and 0.3900 kg of water is evaporated every 3.000 min. Find the temperature of the bottom plate of the pot, which is in contact with the stove. (Thermal conductivity of steel k_{steel}= 50.20 W/m.K; heat of vaporization of water L_V = 2256 kJ/kg)

A) 105.5 °C
B) 103.1 °C
C) 111.9 °C
D) 114.0 °C
E) 107.8 °C

Q13.
Which of the following ideal gases has the highest root-mean-square speed?

A) Nitrogen (M=28 g/mol) at a temperature of 30 °C
B) Argon (M=40 g/mol) at a temperature of 30 °C
C) Nitrogen (M=28 g/mol) at a temperature of 10 °C
D) Oxygen (M=32 g/mol) at a temperature of 30 °C
E) Nitrogen (M=28 g/mol) at a temperature of 15 °C

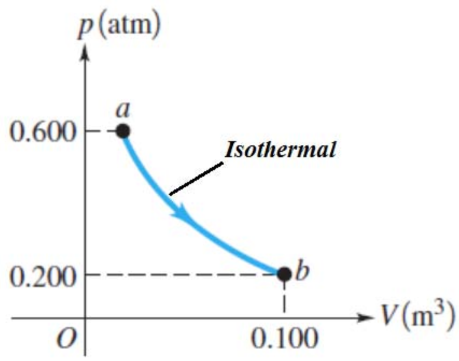
Q14.
A spherical balloon of volume 4.00×10^3 cm^3 contains ideal gas helium at a pressure

of 1.20×10^5 Pa. How many mol of helium are in the balloon if the average kinetic energy of the helium atoms is 3.60×10^{-22} J?

A) 3.32
B) 1.21
C) 1.55
D) 2.33
E) 4.11

Q15.
In the isothermal process ***a→b*** shown in **Figure 5**, the temperature of an ideal gas remains constant at 85.0 °C. Find the magnitude of the work done by the gas during the process *a→b*.

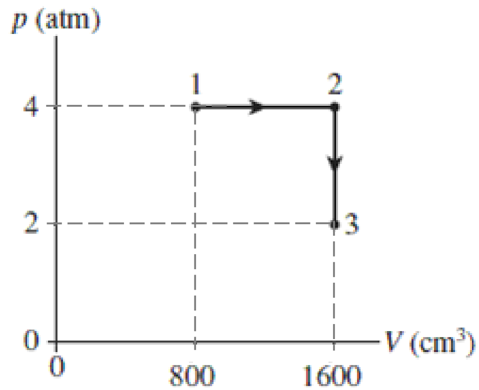
Fig#



A) 2.22×10^3 J
B) 1.90×10^3 J
C) 3.43×10^3 J
D) 4.27×10^3 J
E) 5.51×10^3 J

Q16.
A monatomic ideal gas with 0.10 mol follow the processes 1 →2 and 2 →3, as shown in **Figure 6**. Determine the net heat exchanged during these processes (1 →2 and 2 →3).

Fig#



A) +323 J
B) −323 J
C) +271 J
D) −271 J
E) +110 J

Q17.
An ideal diatomic gas with 0.500 mol at T=273 K temperature and 1.00 atm pressure is compressed adiabatically to a pressure of 20.0 atm. What is the magnitude of the work done on the gas?

A) 3.84×10^3 J
B) 3.00×10^3 J
C) 2.85×10^3 J
D) 2.11×10^3 J
E) 1.84×10^3 J

Q18.
Which of the following statement is **True** about change in entropy per cycle of a Carnot engine ΔS_{carnot}, a real engine ΔS_{real}, and a perfect engine $\Delta S_{Perfect}$ (impossible to build) working between the same hot reservoir (with temperature T_H) and cold reservoir (with temperature T_L)?

A) $\Delta S_{carnot} = 0$; $\Delta S_{real} > 0$; $\Delta S_{Perfect} < 0$
B) $\Delta S_{carnot} > 0$; $\Delta S_{real} = 0$; $\Delta S_{Perfect} < 0$
C) $\Delta S_{carnot} = 0$; $\Delta S_{real} > 0$; $\Delta S_{Perfect} = 0$
D) $\Delta S_{carnot} = 0$; $\Delta S_{real} = 0$; $\Delta S_{Perfect} < 0$
E) $\Delta S_{carnot} < 0$; $\Delta S_{real} = 0$; $\Delta S_{Perfect} < 0$

Q19.
The efficiency of a real heat engine operating between a hot reservoir at 500 °C and a cold reservoir at 0.000 °C, is 60.0 % of the efficiency of a Carnot engine operating between the

same hot and cold reservoirs. If the real heat engine and the Carnot engine do the same amount of work, what is the ratio $Q_{H\text{-real}} / Q_{H\text{-Carnot}}$?

A) 1.67
B) 1.44
C) 1.87
D) 1.91
E) 1.99

Q20.
The coefficient of performance of a refrigerator is 5.0. The compressor uses 10 J of energy per cycle. How much heat energy is exhausted per cycle?

A) 60 J
B) 45 J
C) 55 J
D) 72 J
E) 79 J

$$y = y_m \sin(kx - \omega t), \quad \omega = \frac{2\pi}{T}, \; k = \frac{2\pi}{\lambda}$$

$$\mathrm{v} = \sqrt{\frac{\tau}{\mu}}, \quad \mathrm{P}_{\mathrm{avg}} = \frac{1}{2}\mu v \omega^2 \, \mathrm{y_m}^2,$$

$$y = 2y_m \cos(\phi/2) \sin(kx - \omega t + \phi/2)$$

$$y = 2y_m \sin(kx) \cos(\omega t)$$

$$f_n = \frac{nv}{2L} \qquad n = 1, 2, 3 \ldots.$$

$$f_n = \frac{nv}{4L} \qquad n = 1, 3, 5 \ldots.$$

$$s = s_m \cos(kx - \omega t), \; \Delta p = \Delta p_m \sin(kx - \omega t)$$

$$\Delta p_m = \rho v \omega s_m, \quad \mathrm{I} = \frac{1}{2}\rho v \omega^2 \, \mathrm{s_m}^2, \; \beta = 10 \log\left(\frac{\mathrm{I}}{\mathrm{I_o}}\right)$$

$$\mathrm{v} = \sqrt{\frac{B}{\rho}}, \quad \mathrm{I} = \frac{\mathrm{P_s}}{4\pi R^2}, \quad \Delta L = \frac{\lambda}{2\pi}\varphi,$$

$$\Delta L = m\lambda, \quad \Delta L = \left(m + \tfrac{1}{2}\right)\lambda \quad m = 0, 1, 2 \ldots.,$$

$$f' = \left(\frac{v \pm v_D}{v \pm v_s}\right) f$$

$$T_c = T - 273, \quad T_F = \frac{9}{5} T_C + 32$$

$$\Delta L = \alpha L \Delta T, \quad \Delta V = \beta V \Delta T, \quad \beta = 3\alpha$$

$$Q = mL, \quad Q = mc\Delta T, \quad W = \int P dV$$

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

$$P_{cond} = \frac{kA(T_H - T_C)}{L}, \qquad P_{rad} = \sigma \varepsilon A T^4$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}, \quad K_{av} = \frac{3}{2}kT, \quad PV = nRT = NkT$$

$$Q = nc_P \Delta T, \quad Q = nc_V \Delta T, \quad C_P = C_V + R$$

$$W = nRT \ln\left(\frac{V_f}{V_i}\right), \quad P_i V_i^{\gamma} = P_f V_f^{\gamma}, \quad \gamma = \frac{C_p}{C_v}$$

$$\Delta S = \int_i^f \frac{dQ}{T}, \qquad \Delta S = nR \ln\left(\frac{V_f}{V_i}\right) + nC_V \ln\left(\frac{T_f}{T_i}\right)$$

$$W = |Q_H| - |Q_L|, \qquad \varepsilon_c = 1 - \frac{T_L}{T_H}$$

$$\varepsilon = \frac{W}{Q_H}, \qquad K = \frac{Q_L}{W}, \qquad K_C = \frac{T_L}{T_H - T_L}$$

Constants:

$\mathrm{I_o} = 10^{-12}$ W/m^2

1 Liter = 10^{-3} m^3

1 atm = 1.01×10^5 N/m^2

R = 8.31 J/mol K

N_A = 6.02×10^{23}

k = 1.38×10^{-23} J/K

μ = micro = 10^{-6}, n = nano = 10^{-9}

v = 343 m/s

σ = 5.67×10^{-8} W/(m^2.K^4)

For water:

c = 4190 J/kg.K

L_F = 333 kJ/kg

L_V = 2256 kJ/kg