

Q1.

A string has a mass of 0.20 g and a length of 1.6 m. A sinusoidal wave is travelling on this string, and is given by: $y(x,t) = 0.030 \sin(0.30x - 80t + 3\pi/2)$ (SI units). What is the magnitude of the tension in the string?

- A) 8.9 N
- B) 3.3 N
- C) 4.7 N
- D) 9.2 N
- E) 5.4 N

Sec# Wave - I - The speed of a Traveling Wave
Grade# 58

Q2.

The average power transmitted by a sinusoidal wave on a stretched string does not depend on

- A) the length of the string.
- B) the frequency of the wave.
- C) the wavelength of the wave.
- D) the tension in the string.
- E) the amplitude of the wave.

Sec# Wave - I - Energy and Power of a Traveling String Wave
Grade# 53

Q3.

A standing wave is established on a 3.0 m long string fixed at both ends. The string vibrates in three loops with an amplitude of 1.0 cm. If the wave speed is 100 m/s, what is the frequency?

- A) 50 Hz
- B) 100 Hz
- C) 33 Hz
- D) 25 Hz
- E) 10 Hz

Sec# Wave - I - Standing Waves and Resonance
Grade# 58

Q4.

A string of length 2.5 m is fixed at both ends. A standing wave of frequency 100 Hz is set up on the string. The distance between two adjacent nodes is 0.50 m. What is the fundamental frequency of the string?

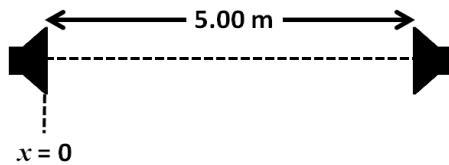
- A) 20 Hz
- B) 100 Hz
- C) 40 Hz
- D) 500 Hz
- E) 60 Hz

Sec# Wave - I - Standing Waves
Grade# 53

Q5.

Two speakers, facing each other and separated by a distance of 5.00 m, are driven by the same oscillator, as shown in **Figure 1**. A listener starts walking from the left speaker toward the right one, along the line joining them. He hears the first minimum at $x = 1.00$ m. Find the frequency of the oscillator. Speed of sound = 343 m/s.

Fig#



- A) 57.2 Hz
- B) 114 Hz
- C) 42.9 Hz
- D) 85.8 Hz
- E) 34.3 Hz

Sec# Wave - II - Interference
Grade# 48

Q6.

A point source uniformly emits 440 W of sound in all directions. How far from the source will the sound level be 106 dB?

- A) 29.7 m
- B) 21.8 m
- C) 32.5 m
- D) 38.1 m
- E) 52.5 m

Sec# Wave - II - Intensity and Sound Level
Grade# 48

Q7.

A train approaches a mountain at a speed of 20.8 m/s. The train's engineer sounds a whistle that emits sound with a frequency of 420 Hz. What will be the frequency of the sound reflected from the mountain, as heard by the engineer? Speed of sound = 343 m/s.

- A) 474 Hz
- B) 430 Hz
- C) 446 Hz
- D) 420 Hz
- E) 400 Hz

Sec# Wave - II - The Doppler Effect
Grade# 43

Q8.

Tube A has length L_A and is open at both ends. Tube B has length L_B and is closed at one end. If the fundamental frequencies of the two tubes match then:

- A) $L_B = L_A/2$
- B) $L_B = L_A$
- C) $L_B = L_A/4$
- D) $L_B = 2 L_A$
- E) $L_B = 4 L_A$

Sec# Wave - II - Source of Musical Sound
Grade# 55

Q9.

A bridge is made of segments of concrete, each of length $L = 50$ m, that are placed end to end. Every two adjacent segments are separated by a spacing ΔL to allow for thermal expansion, without the two segments touching. If the temperature changes by 150 F°, what should be the minimum value of ΔL ? The coefficient of linear expansion of concrete is 12×10^{-6} (°C)⁻¹.

- A) 5.0 cm
- B) 7.5 cm
- C) 10 cm
- D) 2.5 cm
- E) 9.5 cm

Sec# Temperature, Heat, and the First Law of Thermodynamics - Thermal Expansion
Grade# 58

Q10.

A 4.0 kg block of ice at 0.0 °C is mixed with 4.0 kg of steam at 100 °C. What is the final equilibrium temperature of the system?

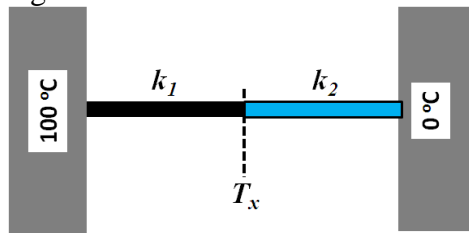
- A) 100 °C
- B) 0.0 °C
- C) 50 °C
- D) 85 °C
- E) 22 °C

Sec# Temperature, Heat, and the First Law of Thermodynamics - The Absorption of Heat by Solids and Liquids
Grade# 48

Q11.

Two rods, made of different materials but having the same length and diameter, are welded end to end between two thermal reservoirs, as shown in **Figure 3**. In steady state, what is the temperature (T_x) at the junction between the two rods?

Fig#



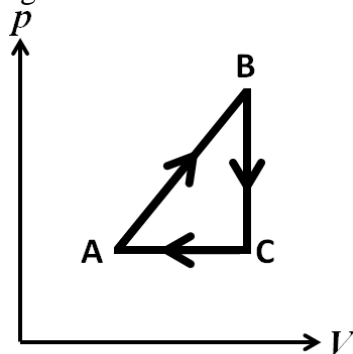
- A) $100 k_1 / (k_1 + k_2)$
- B) $100 k_2 / (k_1 + k_2)$
- C) $100 k_1 k_2 / (k_1 + k_2)$
- D) $50 k_1 / (k_1 + k_2)$
- E) $50 k_2 / (k_1 + k_2)$

Sec# Temperature, Heat, and the First Law of Thermodynamics - Heat Transfer Mechanisms
Grade# 50

Q12.

An ideal gas undergoes the cyclic process shown in **Figure 2**. What are the signs of the heats Q_{AB} , Q_{BC} , Q_{CA} , respectively?

Fig#



- A) positive, negative, negative
- B) positive, negative, positive
- C) positive, positive, negative
- D) negative, positive, positive
- E) negative, positive, negative

Sec# Temperature, Heat, and the First Law of Thermodynamics - The First Law of Thermodynamics
Grade# 45

Q13.

Two moles of a monatomic ideal gas are initially at 27.0 °C and occupy a volume of 20.0 L. The gas is expanded at constant pressure until the volume is doubled. Find the change in the internal energy of the gas.

- A) 7.48 kJ
- B) 12.5 kJ
- C) 0.673 kJ

- D) 1.12 kJ
- E) 5.44 kJ

Sec# The kinetic Theory of Gases - The Molar Specific Heats of an Ideal Gas
Grade# 48

Q14.

An ideal diatomic gas, initially at 20.0 °C, is compressed adiabatically from 1.00 L to 0.500 L. What is the final temperature of the gas?

- A) 387 K
- B) 299 K
- C) 465 K
- D) 305 K
- E) 117 K

Sec# The kinetic Theory of Gases - The Adiabatic Expansion of an Ideal Gas
Grade# 53

Q15.

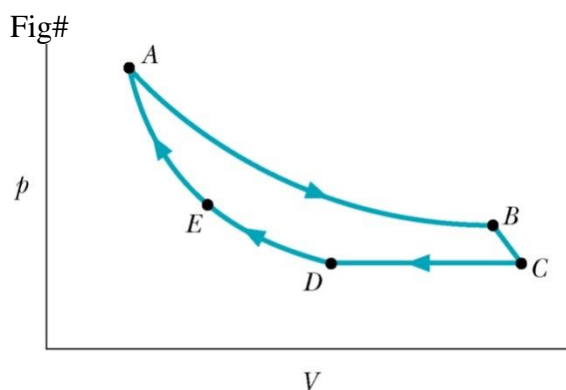
The speeds of four particles are as follows: $v_1 = 1.0$ m/s, $v_2 = 2.0$ m/s, $v_3 = 3.0$ m/s and $v_4 = 4.0$ m/s. What is their root mean square speed?

- A) 2.7 m/s
- B) 2.5 m/s
- C) 1.9 m/s
- D) 5.5 m/s
- E) 3.2 m/s

Sec# The kinetic Theory of Gases - Pressure, Temperature and RMS Speed
Grade# 43

Q16.

Figure 4 shows a cycle consisting of five paths: AB is isothermal at 300 K, BC is adiabatic with work = 8.0 J, CD is isobaric at 5.0 atm, DE is isothermal, and EA is adiabatic with a change of internal energy of 10 J. What is the change in the internal energy of the gas along path CD ?



- A) - 2.0 J
- B) + 2.0 J

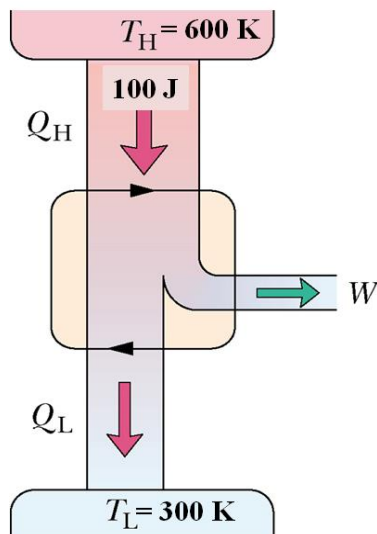
- C) - 12 J
- D) + 12 J
- E) - 18 J

Sec# The kinetic Theory of Gases - Translational Kinetic Energy
Grade# 48

Q17.

A real heat engine is represented by the diagram shown in **Figure 5**. The heat expelled to the low-temperature reservoir can be

Fig#



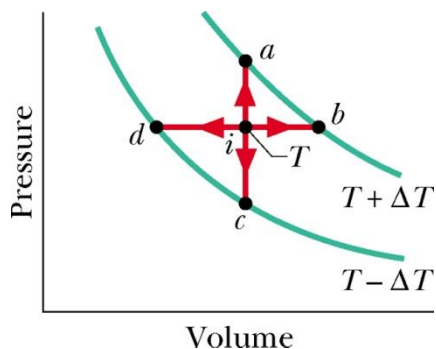
- A) 60 J
- B) 40 J
- C) 20 J
- D) 10 J
- E) zero

Sec# Entropy and the Second Law of Thermodynamics - Entropy in the Real World:
Engines
Grade# 43

Q18.

Point *i* in **Figure 6** represents the initial state of an ideal gas at temperature *T*. Rank the entropy changes that the gas undergoes as it moves reversibly from point *i* to points *a*, *b*, *c*, and *d*, greatest first.

Fig#



- Volume
- A) b, a, c, d
 - B) a, b, c, d
 - C) b, d, a, c
 - D) (b and d tie), (a and c tie)
 - E) (b and d tie), a, c

Sec# Entropy and the Second Law of Thermodynamics - Change in Entropy
Grade# 45

Q19.

In an experiment, 200 g of aluminum at 100 °C is mixed with 200 g of water at 20 °C. The final equilibrium temperature is 34 °C. What is the change in entropy of the aluminum-water system? The specific heat of aluminum is 900 J/kg.K.

- A) + 4.1 J/K
- B) + 74 J/K
- C) - 74 J/K
- D) - 4.1 J/K
- E) zero

Sec# Entropy and the Second Law of Thermodynamics - Change in Entropy
Grade# 50

Q20.

A Carnot refrigerator operates between two reservoirs at - 3.0 °C and 27 °C. How long should the refrigerator be operated, with a 500 W power input, in order for it to absorb 4500 J of heat from the cold reservoir?

- A) 1.0 s
- B) 5.0 s
- C) 2.7 s
- D) 6.3 s
- E) 1.6 s

Sec# Entropy and the Second Law of Thermodynamics - Entropy in the Real World:
Refrigerators
Grade# 53

Test Expected Average = 50

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

$$v = \sqrt{\frac{B}{\rho}}$$

$$y = y_m \sin(kx - \omega t)$$

$$P = \frac{1}{2} \mu \omega^2 y_m^2 v$$

$$S = S_m \cos(kx - \omega t)$$

$$\Delta P = \Delta P_m \sin(kx - \omega t)$$

$$\Delta P_m = \rho v \omega S_m$$

$$I = \frac{1}{2} \rho (\omega S_m)^2 v$$

$$\beta = 10 \log \left(\frac{I}{I_0} \right)$$

$$I = \frac{P_s}{4\pi r^2}$$

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

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

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

$$f_n = \frac{nv}{2L}, \quad n = 1, 2, 3, \dots$$

$$f_n = \frac{nv}{4L}, \quad n = 1, 3, 5, \dots$$

$$\Delta L = \frac{\lambda}{2\pi} \phi$$

$$\Delta L = m\lambda \quad m = 0, 1, 2, \dots$$

$$\Delta L = \left(m + \frac{1}{2} \right) \lambda, \quad m = 0, 1, 2, \dots$$

$$T_c = T - 273$$

$$T_F = \frac{9}{5} T_C + 32$$

$$\Delta L = \alpha L \Delta T$$

$$\Delta V = \beta V \Delta T$$

$$PV = nRT = NkT$$

$$PV^\gamma = \text{constant}$$

$$TV^{\gamma-1} = \text{constant}$$

$$Q = mL$$

$$Q = mc\Delta T$$

$$Q = n C_V \Delta T$$

$$Q = n C_P \Delta T$$

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

$$\Delta E_{\text{int}} = n C_V \Delta T$$

$$C_P - C_V = R$$

$$W = \int PdV$$

$$W = nRT \ln(V_f/V_i)$$

$$P_{\text{cond}} = \frac{Q}{t} = \frac{kA(T_H - T_C)}{L}$$

$$\frac{mv^2}{2} = (3/2)kT$$

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$W = Q_H - Q_L$$

$$\varepsilon = \frac{W}{Q_H} = 1 - \frac{Q_L}{Q_H}$$

$$K = \frac{Q_L}{W}$$

$$\frac{Q_L}{Q_H} = \frac{T_L}{T_H}, \quad \Delta S = \int \frac{dQ}{T}$$

Constants:

$$1 \text{ Liter} = 10^{-3} \text{ m}^3$$

$$1 \text{ atm} = 1.01 \times 10^5 \text{ N/m}^2$$

$$R = 8.31 \text{ J/mol K}$$

$$N_A = 6.02 \times 10^{23} \text{ molecules/mole}$$

$$k = 1.38 \times 10^{-23} \text{ J/K}$$

$$I_0 = 10^{-12} \text{ W/m}^2$$

For water:

$$c = 4190 \text{ J/kg.K}$$

$$L_F = 333 \text{ kJ/K}$$

$$L_V = 2256 \text{ kJ/K}$$