Q1. A sinusoidal wave travels along a stretched string. The time for a particular point to move from maximum displacement to zero is 0.17 s. If the wavelength of the wave is 1.8 m what is the wave speed?

A) 2.65 m/s
B) 10.6 m/s
C) 1.23 m/s
D) 3.96 m/s
E) 7.45 m/s

Q2. Two string, 1 and 2, are made of same material but area of cross-section of string 2 is twice of that the string 1. Both strings are under same tension. The string 1 transmits an average power P_1 if a wave with frequency ω and amplitude y_m is travelling along it. Find the average power transmitted along the string 2 if the same wave (of frequency ω and amplitude y_m) passes through the string 2.

A) 1.4 P_1
B) 2.0 P_1
C) 2.8 P_1
D) P_1
E) 3.5 P_1

Q3. A wave in a string is given by the equation:

$$y(x,t) = 0.240\sin(3.00x - 24.0t),$$

Where x and y are in meters and t is in seconds. Calculate the magnitude of the transverse acceleration of the string element at x = 2.00 m and t = 1.00 s.

A) 104 m/s^2
B) 49.3 m/s^2
C) 91.3 m/s^2
D) 57.7 m/s^2
E) 124 m/s^2

Q4. A rope, under a tension of 400 N and fixed at both ends, oscillates in a second-harmonic standing wave pattern. The displacement of the rope is given by:

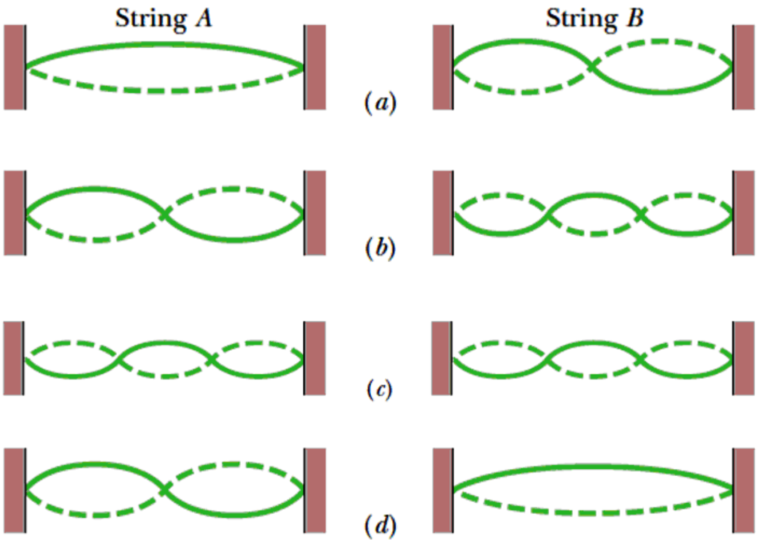
$$y = (0.10\text{ m})(\sin \pi x/2)(\sin 12\pi t)$$

Where $x = 0$ at one end of the rope, x and y is in meters, and t is in seconds. What is the mass per unit length of the rope?

A) 0.694 kg/m
B) 3.78 kg/m
C) 0.356 kg/m
D) 9.24 kg/m
E) 0.243 kg/m

Q5. Strings A and B have identical lengths and linear densities, but string A is under greater tension than string B. **Figure 1** shows four situations, in which standing wave patterns exist on the two strings. In which situation(s) is there the possibility that strings A and B are oscillating at the same resonant frequency?

Fig#



A) a and b
B) a, b, and c
C) d only
D) c only
E) a and d

Q6. sound wave in air produces a pressure variation given by

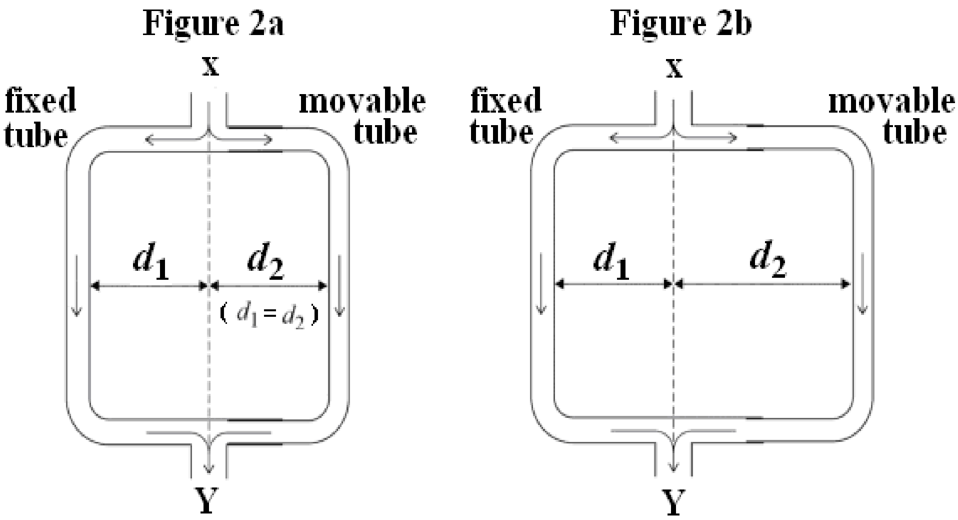
$$\Delta p(x,t) = 0.75\cos[\frac{\pi}{2}(x - 343t)]$$

Where p is in pascal, x and t are in meters and seconds, respectively. What is the displacement amplitude s_m for the sound wave if the air density is 1.21 kg/m^3?

A) 3.35×10^{-6} m
B) 5.27×10^{-6} m
C) 1.81×10^{-6} m
D) 2.16×10^{-6} m
E) 7.59×10^{-6} m

Q7. **Figure 2a** A loudspeaker at X produces sound waves of frequency 171 Hz. The sound waves enter the tube and the sound energy is devided equally before travelling along the fixed and movable tubes. Intially the distance $d_1 = d_2$ (**Figure 2a**), then the moveable tube is slowly pulled out as shown in **Figure 2b**, find the d_2-d_1 for which the microphone at Y detects first minima in sound intensity.

Fig#



A) 0.50 m
B) 1.0 m
C) 2.0 m
D) 1.5 m
E) 0.25 m

Q8. A well with vertical sides and water at the bottom resonates at 9.00 Hz and at no lower frequency. Find the depth of the well. (Speed of sound in air 343 m/s)

A) 9.53 m
B) 20.1 m
C) 15.3 m
D) 6.52 m
E) 2.69 m

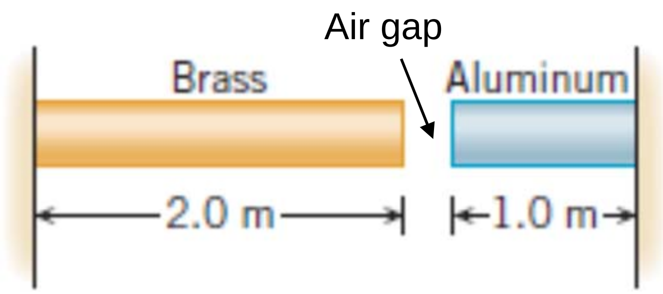
Q9. A block with a speaker fixed to it, is connected to a spring and oscillating on a frictionless surface, as shown in **Figure 3**. The speaker emits sound waves of frequency 440 Hz. If the maximum speed of the block during oscillation is 20 m/s find the minimum frequency recorded by the observer standing in front of the speaker.

Fig#

A) 416 Hz
B) 467 Hz
C) 250 Hz
D) 376 Hz
E) 440 Hz

Q10. The brass and aluminum bars shown in **Figure 4** are attached to fixed walls. At 27 ºC the air gap between the rods is 1.3×10^{-3} m. At what temperature will the gap be closed? (Coefficient of linear expansion of brass and aluminum are 19×10^{-6} /Cº and 23×10^{-6} /Cº, respectively)

Fig#



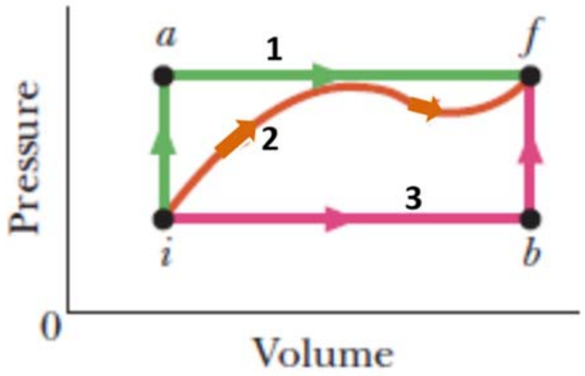
A) 48 ºC
B) 60 ºC
C) 35 ºC
D) 72 ºC
E) 57 ºC

Q11. What mass of steam initially at 100 °C is needed to warm 200 g of water (in a thermally isolated container) from 20.0 °C to 50.0 °C? (Assume container has negligible heat capacity)

A) 10.2 g
B) 11.2 g
C) 6.72 g
D) 15.2 g
E) 13.2 g

Q12. An ideal gas is taken from state *i* to state *f* along three different paths as shown in **Figure 5**. Rank the heat exchanged with the environment for the three paths, 1 (*iaf*), 2 (*if*), and 3 (*ibf*), **GREATEST FIRST**.

Fig#



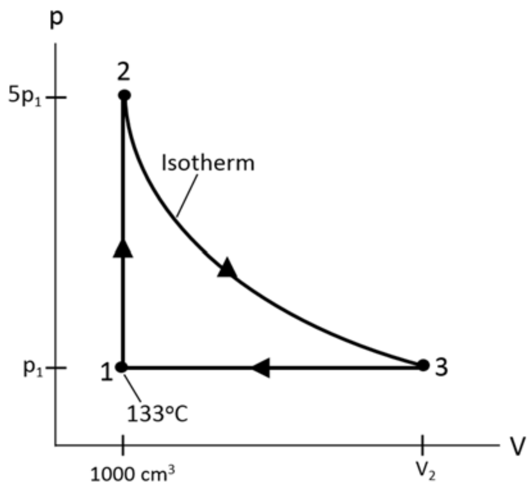
A) 1, 2, 3
B) 1, 3, 2
C) 3, 2, 1
D) 3, 1, 2
E) 2, 3, 1

Q13. A cylindrical metal rod of a length 1.2 m and cross-sectional area 4.2 cm^2 is insulated along its side. One end of the rod is in ice-water mixture and other end is in a mixture of a boiling water and steam. If the ice in ice-water mixture melts at a rate of 20 mg/s find the thermal conductivity of the metal.

A) 190 W/m.K
B) 122 W/m.K
C) 234 W/m.K
D) 319 W/m.K
E) 167 W/m.K

Q14. **Figure 6** shows a thermodynamics process followed by 2.00 moles of an ideal gas. Calculate the heat energy absorbed by the gas during the process 2 to 3.

Fig#



A) 5.43×10^4 J
B) 1.09×10^4 J
C) 7.29×10^4 J
D) 3.71×10^4 J
E) 6.81×10^4 J

Q15. At what temperature do ***atoms of helium*** gas have the same rms speed as ***molecules of hydrogen*** gas at 20 °C? (Molar mass of H and He is 1.0 g/mole and 4.0 g/mole, respectively)

A) 313 °C
B) 980 °C
C) 785 °C
D) 120 °C
E) 260 °C

Q16. When 21.0 J are added as heat to an ideal gas, the volume of the gas changes from 5.00 cm^3 to 100 cm^3 while the pressure remains at 1.00 atm. Find the molar specific heat C_p of the gas.

A) 18.2 J/mol.K
B) 12.2 J/mol.K
C) 21.7 J/mol.K
D) 16.7 J/mol.K
E) 27.7 J/mol.K

Q17. A 0.005 mol of monatomic gas expands adiabatically from an initial pressure of 5.00 atm and temperature of 500 K to a final pressure of 1.00 atm. Find the work done by the gas.

A) +14.8 J
B) –14.8 J
C) –9.27 J
D) +9.27 J
E) –11.4 J

Q18. A 0.500 kg copper block, with an initial temperature of 130 ^{o}C, dropped into a lake whose temperature is 15.0 ^{o}C. What is the entropy change of the lake? (The specific heat of copper is 386 J/kg.K.)

A) +77.1 J/K
B) –77.1 J/K
C) 0
D) –105 J/K
E) +836 J/K

Q19. A 600 W Carnot engine operates between 100 ^{o}C and 60.0 ^{o}C. What is the rate at which energy is exhausted by the engine as heat?

A) 5.00 kJ/s
B) 0.672 kJ/s
C) 4.40 kJ/s
D) 0.0720 kJ/s
E) 5.61 kJ/s

Q20. Which of the following statements is true about the entropy per cycle for (a) Carnot refrigerator, (b) a real refrigerator, and (c) a perfect refrigerator (an imaginary refrigerator)?

A) (a) remains constant, (b) increases, (c) decreases
B) (a) remains constant, (b) increases, (c) remains constant
C) (a) increases, (b) decreases, (c) remains constant
D) (a) decreases, (b) decreases, (c) decreases
E) (a) increases, (b) increases, (c) increases

$$v = \sqrt{\frac{\tau}{\mu}} \quad ; \quad k = \frac{2\pi}{\lambda}$$

$$v = \sqrt{\frac{B}{\rho}} \quad ; \quad \omega = \frac{2\pi}{T}$$

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

$$P_{avg} = \frac{1}{2}\mu\omega^2\, y_m^2\, v$$

$$s = s_m \cos(kx - \omega t)$$

$$\Delta p = \Delta p_m \sin(kx - \omega t)$$

$$\Delta p_m = \rho v \omega s_m$$

$$I = ½\, \rho\, (\omega S_m)^2\, v$$

$$\beta = 10\log\left(\frac{I}{I_o}\right), \quad I_o = 10^{-12}\ W/m^2$$

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

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

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

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

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

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

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

$$\Delta L = m\lambda \qquad m = 0,1,2,....$$

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

$$T_c = T - 273$$

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

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

$$\Delta V = \beta V \Delta T\ ; \quad \beta = 3\alpha$$

$$PV = nRT = NkT$$

$$PV^{\gamma} = \text{constant} \ ; \quad \gamma = \frac{C_P}{C_V}$$

$$TV^{\gamma-1} = \text{constant} \ ; \quad T^{\gamma}P^{1-\gamma} = \text{constant}$$

$$\Delta S = nR\ln\frac{V_f}{V_i} + nC_V \ln\frac{T_f}{T_i}$$

$$Q = mL$$

$$Q = mc\Delta T$$

$$Q = n\, C_V\, \Delta T$$

$$Q = n\, C_P\, \Delta T$$

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

$$\Delta E_{int} = nC_V \Delta T$$

$$C_p - C_v = R$$

$$W = \int PdV$$

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

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

$$\frac{m\overline{v^2}}{2} = (3/2)kT$$

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

$$W = Q_H - Q_L$$

$$\varepsilon = \frac{W}{Q_H} \quad , \quad \varepsilon_C = 1 - \frac{Q_L}{Q_H} = 1 - \frac{T_L}{T_H}$$

$$K = \frac{Q_L}{W} \quad , \quad k_C = \frac{Q_L}{Q_H - Q_L} = \frac{T_L}{T_H - T_L}$$

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

Constants:

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

1 atm = 1.01 x 10^5 N/m^2

R = 8.31 J/mol K

N_A = 6.02 x 10^{23} molecules/mole

k = 1.38 x 10^{-23} J/K

μ = micro = 10^{-6}

Speed of sound in air at room temperature=V=343 m/s

For water:

c = 4190 J/kg.K

L_F = 333 kJ/kg

L_V = 2256 kJ/kg